THE BEAVER

EDWARD ROYAL WARREN

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THE BEAVER

A FIFTY-FIVE POUND BEAVER

MONOGRAPHS OF THE
AMERICAN SOCIETY OF MAMMALOGISTS

NUMBER 2

THE BEAVER

ITS WORK AND ITS WAYS

BY

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TO

S., M., R., and M.

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INTRODUCTION

There are other books about the beaver, one of which, Morgan's "The American Beaver and His Works," will always be a classic on the subject. Morgan's studies were the first attempt to assemble really accurate information as to the habits of the animal, the size and construction of its dams, house and other structures, although Hearne had contributed a great deal to our knowledge, some of which was quoted by Morgan. He wrote, however, almost exclusively about the beavers of the Northern Peninsula of Michigan, and the book was published more than fifty years ago.

Since that time much more has been learned about the animal, and a few books published, but as in Morgan's case, treating mainly of the animal as found in a certain region. Mills's "Beaver World" is on the Longs Peak region, and Dugmore's "Romance of the Beaver" is largely about the Canadian and Newfoundland beaver. Both contain much valuable information.

I have given much time to studying the beaver, mostly in Colorado and the Yellowstone National Park, as well as in such other places as I happened to be and where the animal was to be found. In doing this work I secured considerable information concerning the beaver's habits, and especially about dams and houses, much of which has been published elsewhere. In the course of my studies I came to realize that there was no one book about the beaver which was as comprehensive in its scope as such a book should be, and it seemed to me that such a book was desirable. Hence the attempt to supply this want.

The present book is in no sense a scientific monograph of the beaver. My desire has been to produce something for the lay reader, for the one who cares nothing about subspecies and such matters, but who wants to learn something about the most interesting wild animal on the North American continent, for such the beaver seems to me to be, and judging from my experience with the tourists in the Yellowstone, I am not alone in that opinion. At Camp Roosevelt the visitors were more interested in the beavers than they were in the bears, and that is saying much.

In writing this book I have drawn freely from all the sources of information at my command, books, various scientific papers, my own personal notes, and from correspondence. I have tried to tell the truth about my subject, without humanizing it, but not without acknowledging the wonderful intelligence or specialized instinct, whichever it may be, often displayed in the things it does. If I have been at least partly successful I shall be pleased, especially if I have avoided any serious errors. It would be presumptuous to think there are no errors whatever.

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The authorities of Colorado College gave permission to photograph the stick cut by beaver and shown in figure 72.

CHAPTER I

DESCRIPTION

With the exception of the South American capybara, the beaver is the largest living representative of the order of Rodents, the Gnawers, to which the squirrels, rats, mice and similar animals belong. They are characterized by the large chisel-shaped front teeth or incisors.

In external appearance a beaver is not so very unlike a huge, overgrown muskrat, with a rather short, wide, scaly tail, instead of a long, narrow, thin one, carried edgewise. Adults will run in total length from 40 to 45 inches, possibly more at times, of which length the tail will occupy from 12 to 15 inches.

The color above is a dark brown, with a dusky underfur of a considerably darker shade. The underparts are of a somewhat lighter color, inclining toward a pale chocolate brown. This color of the upper parts is that of the long, coarse outer or guard hairs, which are usually plucked out in preparing the skins for market. The color varies much in different parts of the animal's geographic range, and black, or almost black, examples are not unknown, usually, if not always, from northern or western Canada, while the majority, if not all, of the paler-colored skins come from the southern portion of the beaver's habitat. Vernon Bailey states: "So far as is at present known, the darkest, richest colored, and handsomest beaver fur is found native along the south shore of Lake Superior, in Northern Michigan and Wisconsin. In this region of heavy forests and deep snows the outer hairs of the animals are very dark brown, and the underfur is almost black. When tanned

and plucked the skins are very beautiful, and . . . they almost equal sea otter in depth of fur and richness of color."

Speaking of the fur of the beaver of the Colorado River region, Arizona, Pattie says: "In accommodation to the climate, [it] is becoming short."

Albinos are occasionally found, though they appear to be very rare. MacFarlane thought he had seen perhaps ten during his long period of service with the Hudson's Bay Company. Maximilian said that in 1833 yellowish white and pure white beavers were not infrequently caught in the Yellowstone. Martin, in "Castorologia," states that about 1872 nine pure white beaver skins were secured in one parcel in the neighborhood of Little Slave Lake. R. E. C. Stearns stated that he had seen at Olympia, Washington, a pure white beaver, without the least trace of the usual color. It was taken at or near Goldsborough, 25 miles from Olympia. He also mentioned another specimen, not as pure a white. Both were mounted.

The tail merits a somewhat detailed description. It is of an oval shape, rather thick in the middle and next the body, and thins out both laterally and longitudinally, and there is evidently little or no fleshy matter at the sides and end. Except at the junction with the body, it is covered with a hard, scaly skin, which is very dark, almost black. One examined by me, and which is figured here, was $1\frac{3}{8}$ inches thick where it had been cut off, at the beginning of the scaly part, and was $3\frac{3}{4}$ inches wide at this place. It measured 6 by $10\frac{3}{4}$ inches. There were about eighty-five transverse rows of scales on this tail. There are a few short hairs projecting from between the scales on both sides, though perhaps more abundant on the upper. The part next the body is densely furred. The ratio of the width of the scaly portion to its length varies in different subspecies, and also among individuals of these groups. The width is

UPPER: FIG. 1. A BEAVER'S TAIL

LOWER: FIG. 2. BEAVER SWIMMING, SHOWING CONSPICUOUS EARS

UPPER: FIG. 3. SIDE VIEW OF BEAVER'S SKULL

LOWER: FIG. 4. SIDE VIEW OF BEAVER'S SKULL, WITH INCISOR TEETH
PLACED ON OUTSIDE

from 41 to 48 per cent of the length, and the Carolina beaver, according to the data at my command, has much the broadest tail, that of the type-specimen being 10.8 by 6 inches in size. The connection with the body is comparatively broad and thick, and very muscular while the tail itself is largely composed of fatty tissue. The muscles are powerful and the animal has complete control over them, being able to turn the tail in almost any direction, even completely underneath the body, so that it can sit upon it. An old trapper informed me that a pet beaver owned by him used its tail as a table, placing food upon it. The tail serves as a brace when the owner is standing up cutting down a tree, when it would seem likely that those strong muscles would come in good play. It is used as a rudder when swimming, and at times as a scull to give increased speed, or possibly as a change from using the hind feet. Mills states that he occasionally saw a pet beaver carry mud or other building material clasped between the tail and the body. In diving when alarmed, a beaver often gives an alarm by slapping the water with its tail, making a loud noise, and incidentally splashing water in every direction (Fig. 1).

The eyes are small, and the range of vision is probably limited, though they are quick to detect a moving object. The ears are comparatively short, an inch and a half high, lined with fur, closed when under water, while the hearing is keen. Even though short, the ears are really quite noticeable and prominent when the animal is swimming, or at rest on the surface of the water, being carried erect and standing (Fig. 2) clearly defined against the head. The small nostrils are valvular, like the ears, with large nasal cavities behind them, and the sense of smell is very acute. The mouth has hairy lips closing back of the incisors so as to exclude water when the animal is working below the surface.

The fore paws are small, with fairly long claws, and are

used as hands and for digging. The toes are not webbed. They are not used at all in swimming.

Like the tail the beaver's hind foot deserves a quite detailed description. It is large and webbed, looking something like the foot of a goose, with long, strong toes, each with a good-sized nail. This web extends to the base of the toes. The foot from which this description was made was seven inches long, and could be spread out to a width of more than five. It was thinly haired, mainly of a dark slaty or chocolate color, with some brownish, especially on the part nearest the body. The third and fourth nails were the longest, over an inch in length, while the outer nail was five-eighths of an inch long. The two inner nails are greatly specialized, and have been called the "combing claws."

The claw on the inner toe is formed of two well defined parts. The upper is a quite normally formed and shaped nail, $\frac{1}{4}$ inch wide and $\frac{5}{8}$ inch long. Opposed to this, and smaller, is the other portion, which is not really a nail, but rather a soft lobe, though it does appear to have a little horny substance in it, this being especially noticeable along the edge. The surface opposed to the upper part is somewhat roughened or corrugated. These two parts of the nail are movable and close upon one another, so that if hair is drawn between them it will be thoroughly combed and cleaned.

The second double claw is quite different from the first. It is a double claw, this feature being very noticeable. It has always been known to those who have had anything to do with beavers, while the double character of the outer claw has usually been overlooked. Both parts of this double claw or nail are of typical horny substance, the inner being the upper, and somewhat the longer, and more normally shaped. It is decidedly curved. It measured $\frac{1}{4}$ by $\frac{3}{4}$ inch in the specimen examined.

Below and at the outside is the other half, which is placed edgewise with reference to the first described, with what we may call the underside turned toward the body of the animal. It is thin and rounded at the end, and thick at the base. The dimensions were $\frac{1}{4}$ by $\frac{9}{16}$ inch. These two portions of the claw are movable, and like those of the first claw, can be closed tightly together (Fig. 5).

Vernon Bailey gives the following excellent description of the way in which these claws are used:

"Never until I had tame beavers to study did I fully understand the use and structure of these peculiar nails nor the reason for the incurving form of the two inner toes. My young beavers would sit and comb their fur for a half hour at a time, making elaborate toilets when they had nothing else to do. The curved finger nails of the hands were used on certain parts of the body, around the breast and head, the base of the tail, and especially in the short hair around the anus where the oil from the two oil glands is caught and held for distribution. These finger nails were simply raked through the fur in a coarse combing and oil distributing process, preliminary to the final, thorough combing with the hind feet. Then with one foot at a time the sides, shoulders, and belly were systematically gone over with inward, rotary strokes of the two double claws, until every kink and snarl of the fur was straightened out and not improbably, as Seton suggests, any mites or insect parasites combed out and off."

The hind feet are the chief means of propulsion in swimming.

The two large incisor teeth in each jaw are the tools with which the beaver does his woodcutting, and are excellently adapted to the purpose. The front sides of these teeth are composed of a thin layer of very hard enamel, with a thick layer of comparatively soft dentine behind it. As the

tooth is used the dentine wears away much faster than the enamel, with the result that there is always a chisel edge at the front of the tooth. During the life of the animal these teeth continue growing, and if by any chance there is an injury to a tooth so that it no longer opposes the one in the opposite jaw, the latter may keep on growing until it is of such a length as to be a source of great trouble to the owner even if it does not cause death from starvation from inability to feed. The color of the front of the incisors is a bright orange-red. They are long, and the concealed portions are much curved in the skull and lower jaw. Morgan gives the radius of the curve of the upper incisors as one inch, and of the lower $1\frac{3}{4}$ inches. I obtained somewhat different results in the case of the teeth I measured, these radii being 0.6 and 1.6 inches respectively. Very likely my specimens were from a smaller animal than Morgan's (Figs. 3 and 4).

There are four teeth in the molar series on either side of each jaw, formed of alternate vertical layers of enamel and dentine, which by their unequal wear always afford a good grinding surface.

The muscles on the side of the head which actuate the jaws are thick and powerful, as they need to be to enable the animal to do the work it does with its teeth, such as gnawing wood, tearing out chips, and dragging sticks and logs.

Adult beavers range in weight from forty pounds upward. A sixty-pound one is an unusually heavy one, while seventy pounds is very rare, though Bailey states there are records of old and very fat beavers weighing 100 to 110 pounds. He gives the weight of two two-weeks old beavers at $1\frac{3}{4}$ and 2 pounds respectively.

The genital organs are beneath the skin, protected from the water, and open into the anal cloaca, hence one cannot

UPPER: FIG. 5. HIND FOOT OF BEAVER

LOWER: FIG. 6. SKELETON OF GIANT BEAVER

easily determine the sex of a beaver, except in the case of adult females, which have four teats, two between the fore legs, and two three inches farther back.

There are two pairs of large glands under the skin in front of the rectum. The anterior and larger pair of these are the castoreum sacs, containing castoreum, and the smaller, posterior pair are the oil sacs. More will be said about the castoreum later.

CHAPTER II

ANCESTRY; THE GIANT BEAVER; RACES OF THE BEAVER; DISTRIBUTION; BEAVER PLACE NAMES; HISTORICAL

ANCESTRY

It is rather difficult to write anything definite concerning the ancestry of the beaver, or the genus *Castor*, of which several fossil species have been described in Europe and America. *Steneofiber*, a genus which made its appearance shortly before the middle of the Tertiary Period, in the Middle Oligocene Epoch of Europe, has been said to be the first known ancestor of the beaver. It was about the size of a marmot.

Certain mammals whose remains are found in North America in somewhat later formations were at one time placed in the genus *Steneofiber*, but are now referred to other genera, and are, moreover, placed in different families from *Castor*. *Steneofiber* is therefore not known from North America, and if *Castor* is descended from it, then this latter genus is not really a native of this continent, but an immigrant from Eurasia via the land bridge across Bering Strait.

Castor first appeared in the Pliocene of Europe. I do not know what the forms intermediate between it and *Steneofiber* are, but *Castor* has persisted as a genus to the present day.

An allied genus, *Trogontherium* of Europe, first appeared in the Upper Pliocene, and *T. cuvieri* of the Pleistocene was about one-fifth larger than the modern beaver. It is placed in the family *Castoridæ* with the beaver. In the

First Faunal Subzone the Heidelberg man (*Homo heidelbergensis*) was contemporary with *Trogontherium*, and of course with *Castor fiber*, the European beaver, which existed at the same time. *Trogontherium* survived until the lower part of the Middle Pleistocene.

Castor is widespread in North American Pleistocene, but is lacking from the Pliocene and earlier formations of that continent. It occurs in deposits which are very early Pleistocene, as at Fossil Lake, near Christmas Lake, Oregon; on the Niobrara River, 15 miles from Hay Springs, Nebraska; and the Port Kennedy Cave, Pennsylvania.

Dipoides was a rodent about the size of a marmot whose remains have been found in western North America from the Upper Miocene up to the Pliocene. Matthews and Cook have remarked that *Dipoides* shows a marked approach to *Castoroides*. It may be an ancestor of that genus.

THE GIANT BEAVER, CASTOROIDES

The giant beavers, belonging to the genus *Castoroides*, though closely related to the beaver, are placed in a different family, *Castoroididae*. They were exclusively North American animals.

The geological range of this genus is from deposits which belong very near the beginning of the Pleistocene, upward all through that epoch, while numerous specimens have been found overlying the last or Wisconsin Drift, showing that the animal existed long after the glacial ice had disappeared. In the lower deposits it is found associated with horses and camels, and also with remains of the true beavers of the genus *Castor*. Specimens have been found in many parts of the country from central New York to the Great Plains, and also at Fossil Lake, near Christmas Lake, Oregon; and from Florida to Minnesota. A. G.

Maddren, of the United States Geological Survey, collected part of a femur in Yukon Territory, nearly up to the Arctic Ocean.

The finest specimen of the giant beaver ever discovered is at Earlham College, Richmond, Indiana. It was found in a swamp in Randolph County, Indiana, and was reported to have been discovered "standing in the natural position." It was not quite grown. Though some of the bones were missing it was more nearly complete than any other specimen. The fore feet were missing, and have never been found with other specimens. The specimen was mounted, and a cut is presented herewith, copied from Hay. The fore feet were modeled after those of the beaver, and other missing parts restored from other known specimens.

The total length, measured along the curve of the back as mounted, is seven feet, two inches, about twice the length of a good-sized beaver, but the animal probably was not quite full-grown. Large specimens very likely reached a length of eight or nine feet, more than twice the length of the beaver, "and therefore more than eight times the bulk of the latter." (Hay.) A skull from Iowa was fourteen inches long (Fig. 6).

The incisors were enormous. The upper ones formed about a semicircle, and in the Earlham specimen were 8.14 inches long, measured along the outer curve. On this curve they project forward and downward beyond the bone almost four inches. The width was 0.93 inches, and the thickness from front to back almost as much. These teeth are relatively much larger than in the beaver.

The lower incisors were much longer than the upper; in the Earlham specimen 9.69 inches.

The enamel was not confined to the front of the incisor, as is the case with the beaver, but passed around its whole outer face. It was missing on the other faces. The enamel

was longitudinally grooved, with the grooves separated by sharp ridges. At the tips the incisors were not worn off to a chisel edge, as in the beavers "but in such a way that there is formed between and in the two a deep pit which received the tips of the lower incisors." (Hay.)

Such bones of the hind feet as are known indicate a foot greatly like that of the beaver, though shorter in proportion to the length of the body. Hay makes some comparisons between the leg bones of this animal and those of the beaver which show that the giant beaver was relatively the shorter-legged animal of the two.

"As to the habits of this animal we can make inferences. We may be sure that it was a vigorous gnawer of hard substances. It was almost certainly an aquatic animal. Probably like the beavers it was addicted to cutting down trees and building dams and lodges for the protection of itself and young from cold and enemies. The tail was less expanded than that of the beaver, and possibly the animal had not learned yet to slap the water with it for sport and as a signal of danger. It may have been more flexible, and therefore a better aid in swimming than that of the beaver." (Hay.)

What was supposed to be the house of a giant beaver was discovered near New Knoxville, Ohio, in 1889. It was about eight feet square and between three and four high, and built of willow poles about three inches in diameter, "laid in the manner in which beaver houses are constructed at the present time." The bones of the former owner were found in the house. As bones of deer and other animals were also found there it was supposed that wolves or other carnivorous animals had taken possession after the builder's death.

RACES OF THE BEAVER

As practically always occurs when an animal's habitat includes a considerable territory, especially when the climate and other features are greatly varied, as is the case with the beaver, this animal has developed into a number of geographic races, whose names, with their type localities¹ are given below. No attempt is made to give descriptions of these forms. It is sufficient to say here that they differ in size, proportions, color, and in the characteristics of the skull.

Castor canadensis canadensis Kuhl, Canadian Beaver. Hudson Bay.

Castor canadensis leucodonta Gray, Pacific Beaver. Vancouver Island.

Castor canadensis frondator Mearns, Sonora Beaver; Broad-tailed Beaver.

San Pedro River, Mexico, near Mexican Boundary Monument No. 98.

Castor canadensis carolinensis Rhoads, Carolina Beaver. Dan River, near Danbury, Stokes County, North Carolina.

Castor canadensis pacificus Rhoads, Washington Beaver. Lake Kichelus or Kecheelus, Kittitas County, Washington.

Castor canadensis texensis Bailey, Texas Beaver. Cummings Creek, Colorado County, Texas.

Castor canadensis phaeus Heller, Admiralty Beaver. Pleasant Bay, Admiralty Island, Alaska.

Castor canadensis mexicanus Bailey, Rio Grande Beaver. Ruidoso Creek, 6 miles below Ruidoso, New Mexico.

Castor canadensis michiganensis Bailey, Woods Beaver. Tahquamenaw River (5 miles above falls), Luce County, Michigan.

Castor canadensis belugæ Taylor, Cook Inlet Beaver. Beluga River, Cook Inlet region, Alaska.

Castor subauratus subauratus Taylor, Golden Beaver. Grayson, Stanislaus County, San Joaquin River, California.

Castor subauratus shastensis Taylor, Shasta Beaver. Cassel, (Hat Creek) Pit River, Shasta County, California.

Castor cacaetor Bangs, Newfoundland Beaver. Near Bay St. George, Newfoundland.

¹ The type locality is the locality from which came the specimen from which the first description of a species was made.

The European Beaver

The European beaver, *Castor fiber*, is very similar in appearance to the American animal, but is slightly smaller. There are some differences in the characters of the skull, that of the European animal being the narrower, and having slightly proportionally longer nasal bones.

DISTRIBUTION OF THE BEAVER

Once the American beaver occupied a vast area on the North American continent. This area may be broadly stated as the whole of the United States, overlapping a short distance south into northern Mexico, and in Canada extending north to the limit of the deciduous trees, really to that of the aspen; at the mouth of the Mackenzie River this brings the animal north of the Arctic Circle. Within this range it is absent from the desert regions of southern California, and parts of Utah and Nevada, and most of Florida, Georgia, and North and South Carolina.

The accompanying map (fig. 7), reprinted by courtesy of the United States Biological Survey, shows the former distribution of the beaver and the distribution of the aspen. Taking together the ranges of the various species of birch, these trees cover much the same ground as the aspen, but apparently do not extend quite as far to the north.

Over much of this great area the animal has been exterminated, and probably in much of the remaining part its numbers are greatly diminished. As an offset to this the beaver has been reintroduced in a number of localities, and is doing well in most of these places—too well in some, according to the opinions of some people whose property they have been damaging.

It recently has been reported as having voluntarily re-

FIG. 7. MAP OF NORTH AMERICA SHOWING DISTRIBUTION OF BEAVER AND OF THE ASPEN

Showing the range of the beaver and of the aspen, its principal food tree. The heavy black line shows the original range of the beaver. Though now exterminated in much of the included area, the line probably still shows quite correctly the limits of its range. It is one of the most widely distributed animals in North America. The distribution of the aspen is shown by the shaded area of the map. It is the most widely distributed tree in North America. The genus *Betula*, comprising the various species of birch, is found over most of this same area, and some of the birches are possibly found farther south than the aspen, though not extending as far into the northwest. In the north certain species of birch are important food trees of the beaver, but in the Rocky Mountain and Pacific Coast regions are of no importance whatever.

This map is reproduced by courtesy of the Biological Survey, U. S. Department of Agriculture.

turned to one or two places in West Virginia, in which state it had been considered as extinct for fifty years or more. I have a private letter saying that three colonies have established themselves in New Jersey.

According to Barret-Hamilton and Hinton's *British Mammals*, the Old World beaver once occupied the "Whole of the forested region of Eurasia, from Lapland and northern Russia southwards to Spain, Italy, and the Euphrates, and from Great Britain eastwards at least as far as the Lena. The Asiatic limits of its distribution are, however, still imperfectly known." While the beaver lived in Great Britain, it never was an inhabitant of Ireland.

The same authors state that at the present time, the beaver is found only in southwestern Norway, in the Elbe, and in the delta of the Rhone, in each of which localities it is supposed to enjoy complete protection. The Norwegian colony is the most important. Nothing is said by these authors about the present day distribution in eastern Europe or in Asia.

It is remarked that the colony in the Rhone delta must be one of the most interesting in the world, "for since there is little or no timber at hand, the beavers must lead what is practically the life of a huge water rat."

James O. Pattie's *Narrative* gives us an excellent conception of the number of beavers to be found in some parts of the West a hundred years ago. Trapping on the Gila River and some of its tributaries in Arizona, from the middle of December, 1824, through March, 1825, his party of seven took four hundred and fifty beavers. In one night thirty-seven were taken. In February, 1826, he found the Salt River in Arizona to abound with beaver. In the spring and summer of that year he reported beavers scarce on the South Platte and on the main Platte, owing to continual trapping. The winter of 1827-28 he made another expedi-

tion into Arizona with a party of eight, and took plenty of beavers on the lower Gila in late November. In December he was on the Colorado River, floating down in canoes constructed by his party from logs. The river seems to have had a large beaver population, and he says there were many on the islands in the river. The outfit must have been well supplied with traps, for he says they sometimes took sixty beavers of a morning. One night forty traps were set, and the next morning thirty-six beavers had been captured, "an excellent night's hunt." In fact they caught so many of the animals that they were soon obliged to make another canoe to carry their fur. They already had eight, fastened together in pairs by means of platforms across them.

Franchère reported beavers as common in the country of the Willamette, Oregon, in 1811 to 1814, and Townsend said there were many on the Malade River in 1833.

BEAVER PLACE NAMES

As a natural consequence of its former wide distribution in America the beaver has given its name to many streams, lakes and other natural features, to say nothing of towns. The following list, which includes names of which the word "beaver" forms a part, is taken from the index to maps in the Century Dictionary, edition of 1911. The number following a name signifies that, if more than one, there are so many of that name.

Beaver, 24
 Beaver Bank
 Beaver Brook, 3
 Beaver Center
 Beaver City, 2
 Beaver Cove
 Beaver Creek, 29
 Beaver Creek, 4
 Beaver Crossing
 Beaverdam, 7

Beaver Dam
 Beaverdam Bald, 2
 Beaverdam Creek
 Beaver Dam Creek, 2
 Beaver Dam Lake, 2
 Beaver Dam Mountains
 Beaver Dam Pond
 Beaver Dams
 Beaverfalls
 Beaver Falls, 2

Beaver Harbor, 2	Beaver Meadows
Beaverhead County	Beaver Mouth
Beaver Head River	Beaver Pond
Beaver Head Rocks	Beaverpond, 2
Beaver Hill	Beaver River, 10
Beaverhill	Beaver River Corner
Beaverhill Lake	Beaver River Range
Beaver Island, 2	Beaver Run
Beaver Kill	Beaver Springs
Beaverkill	Beaver Tail Point
Beaver Lake, 7	Beaverton, 5
Beaverlick	Beavertown
Beaver Lick Mountains	Beaver Valley
Beaver Lodge Mountains	Beaverville
Beaver Meadow	

A total of forty-four different names, which would be greater if I counted separately such names as Beaverdam and Beaver Dam, which are really the same, and one hundred and forty places. These names are scattered all over the United States and Canada, and show of themselves how widely distributed the beaver must have been in the past. The list is doubtless incomplete, for in "A Gazetteer of Colorado," published by the United States Geological Survey in 1906, I find fourteen Beaver Creeks, two Beavers (settlements), Beaver Ridge, Beaver Brook (stream), Beaver Brook (station), these last two in different counties, Beaver Creek (postoffice), Beaverdam Creek, Beaver Station, Little Beaver Creek, North Beaver Creek, and I know of a Big Beaver Creek and a Beaver Lake in this state. No doubt the other western states are equally well supplied with beaver place-names.

In England there are various beaver place-names, such as Beverley, Bevercoates, Beversbrooks, Beverstone, Beavbourne, Beaver Island, Beverege, and Beverley Brook.

In my old home, ten miles out from Boston, is a Beaver Brook, where I used to go fishing when a boy, and a Beaver Brook Station on the railroad.

HISTORICAL

The word "beaver" in one form or another is common to Indo-Germanic languages, and is traceable to the Old Aryan *bebhrus*. The old Persian *baðvara* was used to signify the beaver between 300 and 400 B.C. Some, at least, of the ancient Greek writers had a personal knowledge of the animal. Dante, writing in 1310, refers to the beaver in the *Inferno*. In fact the animal lived in the Po as late as the sixteenth century.

"The beaver was undoubtedly a very common British mammal in the later prehistoric periods, and to its activities we may owe some very striking features of the present British landscape."² The fens may have been due to the destruction of the natural drainage by dams and fallen tree trunks. The destruction of the Pennine woodland and the formation of the peat mosses of Lancashire, were the work of the beaver.

"Apart from human persecution, it is perhaps doubtful whether a small island like Britain could have long continued to support a large population of beavers."² It probably did not become extinct on that island before the thirteenth century.

Gerald deBarri, better known as Geraldus Cambrensis, traveled in Wales in 1188 and wrote of the beaver there, describing the construction of their houses. He speaks of their making communications from floor to floor, as if there were more than one story to the structures. The houses are said to be built of willows and other kinds of wood, and different kinds of leaves. Mud is not mentioned in the translation. "In the course of time, their habitations bear the appearance of a grove of willow trees, rude and natural without, but artfully constructed within."

² A History of British Mammals, Barrett-Hamilton and Hinton.

The early history of Canada is full of allusions to the beaver, for the French, from almost the very beginning of the settlement of that region, began the acquisition of beaver skins, either by trading with the Indians, or by other methods. The Jesuit fathers, in their intercourse with the savages, seem to have acquired many skins, and to have had much difficulty in disposing of them. The rules of the order appear to have prohibited any sort of commerce for profit. The company chartered by the king of France had the sole right to trade in any sort of furs, and the Jesuits were obliged to sell to this company for any price it chose to pay.

The first parish church of Quebec was built by a contribution of beaver skins from the governor. The carpet around the altar was paid for by beaver skins.

Beaver skins seem also to have had some symbolical significance among the Indians, apart from their ordinary uses. In some of the Jesuit accounts mention is made of presents of beaver skins being made to different tribes when adjusting disputes between them. The value of the skins themselves was not great, but the sentiment conveyed by them meant much, and served to bind a treaty.

I have said nothing in regard to the traditions and legends of the Indians concerning the beaver. They had many, varying with the different tribes. I think most of the tribes had legends connecting the beaver in some way with the creation of the world. Some tribes possessed the medicine bundle known as the "beaver bundle," which was supposed to have supernatural attributes. The individual possessors or holders of these bundles had special powers due to this ownership. The various Blackfoot tribes seem to have set much store by them.

CHAPTER III

THE INTELLIGENCE OF THE BEAVER

It is not easy to write of the intelligence of the beaver or of that of any other of the lower animals. The opinions of the various writers on the subject vary widely, some crediting the animal with a high degree of intelligence, and others denying that it is possessed of anything more than a highly developed and specialized instinct. Right here we come to the difficulty of defining the difference between instinct and intelligence, or perhaps it might be better to say where one begins and the other ends. Intellectually the beaver is human-like in that it does some very clever things, and it also does some very stupid ones, and it should not be judged solely by either.

The rodents, of which order the beaver is a member, are rather low in the scale, and the brain is smooth, wanting in convolutions, these facts apparently indicating a low mental capacity. The beaver does not differ from other rodents in respect to the structure of the brain.

I find it somewhat difficult to define my own position in the matter. Perhaps it might be well for me to say that I have never made any study of psychology, and whatever opinions I may have are based upon observations made upon animals at various times. I do believe that animals have a certain amount of intelligence, as distinguished from instinct, very likely varying with the different orders, and of course with different individuals.

My studies of the beaver have led me to the conclusion that it does act intelligently, not with the human intelligence some writers would ascribe to it, but that it does do

things in which it is guided by something more than instinct alone. Such things as the selection of the best locations for dams, of which I later give one or two instances, the building of canals with two or more water levels, making a ditch around a rough place in a stream so as to take its logs down with the least trouble, all seem to me to point to the possession of some degree of intelligence. An instinct which tells an animal to do any or all of these things comes so near being intelligence that it may as well be called that.

On the other hand, in the felling of trees, the animals seem often to proceed in an unintelligent manner, and to have no notion as to making a tree fall in the most suitable direction, and especially so as to prevent its entanglement with other trees. Where trees have become entangled with others in falling, the beavers seldom seem to take very obvious methods of freeing them. Mills says that he knew beavers to stop cutting on the windward side of a grove on a windy day, and to go around to the lee side; also not to cut trees whose tops were entangled in the branches of other trees.

Mills firmly believed that the beaver was an intelligent, reasoning animal, and gave various reasons for his belief. Morgan was very much of the opinion that the beaver is possessed of a *free intelligence*, as he termed it, mentioning especially in this connection the interrelation of dams, lodges, and water level. He also thought that while a canal was simpler to construct than a dam, it required more intelligence to plan, which is quite true.

In connection with canals Dugmore says: "These canals, I venture to say, are a demonstration of the highest skill to be found in the work of any animal below man. It is even doubtful whether man in his lowest form does such extraordinary constructive work and with such remarkable

success." He also cites the fact that beavers will turn other streams into their own in order to add to the water supply as something requiring thought.

G. J. Romanes expressed the following opinion: "Most remarkable among rodents for instinct and intelligence, unquestionably stands the beaver. Indeed, there is no animal—not even excepting the ants and bees—whose instinct has risen to a higher level of far-reaching adaptation to certain conditions of environment, or where faculties, undoubtedly instinctive, are more puzzlingly wrought up with faculties no less undoubtedly intelligent."

On the other side Johnson considers the beaver acts entirely from instinct. "But in the course of the ages it has evolved a set of instincts, highly complex, at which we can not but marvel just as we marvel at the instincts of the ant and the bee. These instincts are inherited and at just the right time in their life history, when the proper stimuli prompt them, the young beaver will do certain things, and do them in the same way and just as well as their parents, without first having to be shown or taught how."

Seton says: "While of a low general mentality, the beaver has a wonderfully developed instinct for the building of dams and waterways. A quickness to take advantage of little things and a ready adaptability to change of surroundings that in this special department puts it in the highest class of low animal intelligence. A case parallel with that of the ants indeed; which, though so low in organization, have acquired extraordinarily complex instincts, whose history affords one of the most wonderful 'fairy tales of science.' "

I think Seton puts the case very well when he says that after the beaver had been considered on a par with man intellectually and most wonderful tales were told about it, there was a reaction, and it was put in the same class as the

rabbit and porcupine, as to intelligence. Later, thanks to the work of such observers as Hearne and Morgan, we find, as usual, that the truth is between the two extremes.

That the beaver is adaptable no one who has studied its work will deny. In adapting itself to or taking advantage of circumstances it does just what a human engineer does when, before beginning the construction of a dam, for instance, he studies the surroundings, investigates the proposed site and the character of the underlying rocks or soil, and having gained this knowledge, plans his work accordingly, more elaborate and thorough than what the beaver does, and more consciously done than the beaver's work, perhaps. But the main point is that each adapts itself to circumstances, and if in the case of the man this shows intelligence, why not also in the case of the beaver?

CHAPTER IV

THE DAM

Unless the animals happen to be living in natural ponds or lakes, the dam is almost sure to be the first structure made by the beaver. It is necessary to their existence in many cases, and absolutely essential to their welfare. Therefore in the founding of a new colony dam-building is the first step, and once built, the dam requires constant attention and repair to keep it in condition.

The method of construction appears to be always practically the same at the beginning. Branches of willows, alders, or whatever brush is most available, and this is usually one or both of the two just named, are cut and placed on the bottom with the butt ends upstream, and often forced into the bottom. Mud and gravel, and frequently stones, are put on these branches, this material being obtained from the bottom just above the dam. Other layers of brush are placed upon the first, each in turn weighted down with mud, until the dam reaches the desired height. At first the water leaks through the loosely constructed affair, but the stream brings down sediment which helps to make the dam watertight, more mud is placed on the upper side and on the crest, and soon the dam is holding water, and the pond has filled. A drained beaver pond usually, if not always, has a ditch or trench immediately above the dam from which the earth used in the latter was taken.

Such, in a few words, is the construction of the usual dam. But a dam is never finished as long as the pond is occupied, for it not only requires continual attention to keep it in ordinary repair, but the pond tends to fill up with silt brought

in by the stream, which naturally lessens the depth of the water, and hence the dam must be raised in order to retain the water at the desired depth. Raising the height of the dam almost invariably means lengthening it, and thus a dam, which was originally straight, comes to have a curve up or down stream, or, if it be a long one, may have several angles in it.

In constructing the dam the beaver brings up such materials as mud and stones from the bottom by carrying them held against its chin by its fore feet, which are pretty efficient hands in such work. Mills speaks of seeing his young pet beaver carry mud and sticks clasped between the tail and belly. The branches used are conveyed by holding them in the mouth and letting them trail alongside on the ground or in the water until the dam is reached, where the paws may be used to place them properly. In building dams beavers will often take advantage of any natural elevations which may be of use to them. At one place in Colorado, where a low dam was extended across a wide flat or meadow, and where numerous clumps of willows stood a little higher than the surrounding surface, the animals built their dam from one of these clumps to another, saving themselves considerable labor, though I must confess I thought their work was wasted, for only a very shallow pond was created, of which I was unable to see the use. It was one of those cases where it seemed as if the beaver had made a mistake and failed to accomplish anything.

I have little doubt that at the beginning of the construction of a dam most of the brush used is laid longitudinally with the current, not transversely. Some dams may possibly have all the material laid in this manner. In many cases, however, where dams have been cut through by man or a stream, the ends at the banks remaining, one sees the ends of sticks projecting from the break as if they had been

laid across the stream (Fig. 9). I have seen several instances where this appeared to be quite evident. The sticks here were usually rather small. It also seems possible that some movement may occur in the inevitable settling of a dam which shifts some of the sticks, causing them to take this transverse position. When a dam is completed sticks and brush are often seen lying lengthwise on the top, and the peeled sticks carried there after the bark has been eaten from them lie in various positions, criss-cross, as one writer expresses it. Many sticks of this sort drift to the dam and lodge there. Sticks carried to the lower face of a dam after its completion seem to be dropped there in almost any manner. I have seen one dam in Colorado which had long pine poles placed along its face so that their ends projected quite high above the dam (Fig. 10).

One dam which I found in Colorado, built upon a bench a few feet above the stream, had willow brush laid horizontally between clumps of willows which were along the course of the dam. As the water in the pond came from springs there was practically no current to resist, and this somewhat weak form of construction was of no detriment to the dam.

Dams consisting wholly of mud or sods are sometimes built. The one or two which I have seen were in swampy ground where there was no current, and were made by excavating the material from above the dam and piling it up along the desired location. In one case in the Yellowstone the whole pond was thus excavated in building the dam. This pond was apparently constructed for water storage.

It is sometimes stated that trees are felled across a stream in beginning a dam, but it is exceedingly doubtful if this is ever the case. Morgan mentions one instance where a large fallen pine formed part of a dam, but he was in doubt as to whether the tree had fallen before the beginning of the dam, and thus suggested the site to the beavers, or had fallen on the dam after it was built.

UPPER: FIG. 8. LOWER SIDE OF DAM BUILT OF WILLOWS
LOWER: FIG. 9. BEAVER DAM WHICH HAD BEEN CUT THROUGH TO
DRAIN THE POND

FIG. 10. DAM WITH LONG POLES ON THE FACE

I saw two or three small dams in a group on Tower Creek, Yellowstone Park, where half-decayed pine logs formed part of the dam. I think it probable that the beavers intentionally made use of these fallen logs as part of their dams, which belonged to a series of storage ponds. It certainly seems rather unlikely that several logs should have fallen across so many dams in the same group after the building of the dams. A. H. Howell, in the Biological Survey of Alabama, states that beaver built small dams across Catoma Creek in that state, generally utilizing "trunks of fallen trees (not of their own cutting) for a foundation, filling in the space between the logs with sticks, cane stalks, leaves and mud."

In Gunnison County, Colorado, I found a dam twenty feet long and eight feet wide on top, built across a slough having little or no current. This appeared to be constructed largely of mud, though a certain percentage of sticks was also visible. It was evidently quite old at the time of my examination, but a little work had recently been done on it.

In 1899 a surveyor named John Harrold was running section lines in the Little Missouri Badlands, immediately west of the Killdeer Mountains, North Dakota, and discovered three or four beaver dams built of coal. The face of one of these was six feet high. The coal came from a nearby bluff. Taylor, who is the authority for the above, also mentions dams on the Upper White Earth River, North Dakota, built entirely of stones, some of which would weigh as much as fifty pounds.¹ Mills speaks of a dam in the Sawtooth Mountains, Idaho, constructed of logs from a snowslide. I have myself seen a few sticks from a snowslide utilized in a dam.

Morgan speaks of three dams discovered in Montana which were in a petrified state. "They were not in that

¹ Taylor, Beavers, Their Ways.

complete and final state of petrification which involves the change of every particle of the original woody materials, and the substitution of solid substances; but rather incrustated with lime, which, penetrating and solidifying the entire structures, had given them a permanently durable form." These dams were fifty to sixty feet long, and had a fall of water over them of from one to four feet.

The beaver has been credited with having the intelligence to build its dam with an upstream curve, the better to withstand the force of the current. Just another of the legends about the animal. Sometimes the dams are built in a straight line across the stream, sometimes curved up and sometimes down, and in a long dam often bent both ways indiscriminately. I think they do this without any special reasoning, unless special circumstances force a particular construction. The most peculiar example of a downstream curve which I have seen was on a dam on a small stream in Colorado. When I first saw it I called it a "mule-shoe curve." I examined and measured it. The total length was seventy-one feet. From the end at the right bank of the stream it extended down parallel with the current twenty-four feet. At this point high water had torn a gap five feet wide and swung the broken-out portion downstream in line with the other part. It was twelve feet across at right angles to the stream to where the dam turned up again, and it was about twenty-five feet across between the two ends of the dam. I could see no reason for this manner of construction. There did not appear to have been any obstacle to building a dam directly across the stream, and it seemed possible that the dam had been originally thus built and afterward broken by flood, parts perhaps forced down stream, as I had seen, and their ends later connected to close the gap.

Beaver dams are of all lengths, from the trifling ones a

foot or two long, made to head off a side flow of water, to the one mentioned by Mills, on Jefferson River, near Three Forks, Montana. This was 2140 feet long, most of it old; more than half was under six feet high; two short sections were twenty-three feet wide at the base, five on top, and fourteen feet high. This is, of course, extremely unusual, and unfortunately Mills gives no further details which might explain the reason for this extraordinary length. Undoubtedly it was the work of many generations of beavers, and probably constructed intermittently.

Shiras gives a picture of a dam forming the western end of Echo Lake, which occupies a mile in the center of Grand Island, Lake Superior. The legend under the picture says: "The bank on the left, covered with second growth trees, is an ancient beaver dam 1500 feet long, probably 400 years old, and forming the lake, originally."

I think it doubtful if dams are ever of any great length when first constructed. The great majority are under fifty feet long at first, though I have seen a dam in Colorado which was nearly a hundred feet long as first built, it being necessary for it to be of this length in order to cross the stream. Another below it was seventy-six feet in a straight line from end to end, but curved twice, first down, then upstream, starting from the right bank and ending short of the left. Below this dam, and setting out diagonally into the stream from the left bank, was a short one twenty feet long. The water flowed around the end of the long upper dam, and thence around the free end of the short lower one, thus throwing the main body of water back to the right bank where it would naturally have been if undisturbed by any obstruction, and where it was much deeper than on the opposite side, and therefore keeping the water deep below the dam as well as above. When I first described this place I made the statement that the downward curve of the dam near

the right bank created an eddy and backwater above the dam and threw the swifter current over to the other side into the shallow water. Doubtless this was the case, but from what I have since seen of beaver work I am in doubt as to whether or not that downstream curve was made intentionally.

It may be as well to mention here three dams on the same stream some little distance above those just described. The upper one extended about halfway across the river from the left bank; twenty-five feet below, and on the opposite side,

FIG. 11. MAP OF DAMS DEFLECTING CURRENT BACK TO THE SIDE OF THE STREAM WHERE THE WATER WAS DEEPEST

was another dam also extending halfway across; sixty-five feet below that and on the same side was a third dam, likewise going halfway over. Twenty-five feet below was a small dam about eight feet long. The upper dam backed up considerable water, but, as the stream had too much fall, not to any great depth. The other two dams, while not increasing the depth of the water so very much, did make quiet pools, perhaps more to the beavers' liking than the swift water (Fig. 12).

UPPER: FIG. 12. THE SERIES OF THREE DAMS
LOWER: FIG. 13. A DAM WITH TWO SHARP ANGLES

FIG. 14. A LONG, CROOKED DAM ON THE NORTH FORK OF ELK CREEK,
YELLOWSTONE PARK

To return to the dimensions of dams. I measured the dam which formed Beaver Lake in Yellowstone Park, and found it to be 1054 feet long, this without following accurately all the bends of the dam, which was quite crooked.

The longest dam still used by beavers which I have personally measured was one on the North Fork of Elk Creek, Yellowstone Park. This was three-hundred and fifty feet

FIG. 15. MAP SHOWING TWO DAMS WITH MANY ANGLES IN THEM, NORTH FORK OF ELK CREEK

from end to end, and very crooked. In spite of its length it made only a narrow pond, one hundred feet wide, because of the topography (Fig. 14), the ground being comparatively level in the direction of the dam but rising faster up stream, most of the water entering and leaving towards one side of the pond. This conformation of the surface doubtless explains the irregularities of this and similar dams. The beginning is a

short dam across the stream which forms a pond. The water rises in this, and presently begins to flow around one or both ends of the dam. The beavers extend the dam to cut off the escaping water, and these extensions point up or downstream according to the lay of the land, thus producing an up or downstream curve in the dam, which is thus purely an

FIG. 16. MAP OF PONDS ON THE NORTH FORK OF ELK CREEK, YELLOWSTONE PARK, SHOWING THE CHANGES WHICH WERE MADE IN TWO YEARS

accident and not intentional. The varying curves in such a long dam as the one I have just mentioned are undoubtedly caused by variations in the surface of the ground across which the dam was made, the builders carrying the dam along from point to point as necessary to stop the overflow.

Something over a hundred yards upstream from the above described dam is one which in 1921 was 115 feet long. In

1923 it was 250 feet, more than double its former length, and the pond was proportionately increased in area, and contained a lodge. This increase in size was probably made by beavers which moved up from the large pond below in order to be nearer the aspens, and also possibly because they were crowded out of the other place (Fig. 16).

The height of beaver dams is of course variable. I think a large majority are under five feet high, measuring perpendicularly from the crest to the stream bottom below. Johnson gives the heights of two dams in the Adirondacks as 8 feet 8 inches and 11 feet 1 inch, respectively. These are really very much out of the common, if not extraordinary. One sometimes sees dams but two or three feet high which back the water up for considerable distances. This depends, naturally, upon the fall of the stream; the greater the fall, the higher the dam must be to make a pond of any size and depth. Sometimes comparatively short dams will make large ponds. One dam in the Yellowstone, 103 feet long, was placed at the lower end of a wide, shallow valley, below which the gulch fell off rather abruptly, forming a pond 350 feet long by 225 feet in its greatest width. At Crescent Hill the largest pond, 340 by 800 feet, was formed by a dam 165 feet long. Of course in both cases the locations of the dams were exceptionally favorable for the formation of such large ponds. Frequently it is the other way about, long dams having narrow ponds above them, sometimes not more than a half or a third of the length of the dam in width.

In a stream with a gentle fall a short dam between the banks may make a pond several hundred feet long. I have seen a dam sixty feet long back the water up 475 feet, and another thirty-five feet long make a pond 350 feet in length, and a third dam fifty feet long made a 375 foot pond, all on the same stream. At Little Trappers Lake I found a dam three feet long which backed water up for 75 feet. Johnson

mentions a dam 75 feet long and three feet high on Salmon Brook in the Adirondacks, which made a flow about a mile long.

Beavers sometimes display excellent judgment in locating a dam at the most suitable point to get the best results. At Crescent Hill, Yellowstone Park, the dam making the large pond previously mentioned was placed at the lower end of a gulch between Crescent Hill and a ridge to the east,

FIG. 17. A DAM WHICH COVERED AN ARC OF 225 DEGREES

at a point where the two slopes came closest together; the gulch widened above where the pond was formed, while below the valley spread out and became flatter; this was the place an engineer would have selected for the same purpose. This dam appeared to be rather an old one. Several hundred feet below, along the gulch, the beaver had, in 1921, begun another dam at a similar spot, where the two slopes approached and a comparatively short dam would flood a

good-sized area. In 1923 I found the place in the same condition as when last visited in 1921. Evidently the beavers had decided they did not wish a pond there.

Beavers make mistakes at times in building dams, sometimes because the stream is too turbulent for them to make a permanent structure, or because there is not material for them to work with, or the dam does not make a pond of sufficient size or depth.

Mills mentions a dam which by successive additions came to extend three-fourths of the way around the pond. I saw a small abandoned pond near Yancey's, the dam to which partially encircled the pond and described an arc of 225 degrees, though far from circular. The pond was situated where the North Fork of Elk Creek entered the valley. The pond was so filled up with gravel that but little could be learned about the history of the dam.

Dugmore says that alders are most frequently used in building dams. I presume that refers to the regions where most of his observations were made, Canada and Newfoundland. If I were to go according to my own work, I should say willow, and as a matter of fact I think the animals use the materials which are most available. He states that a week of steady work on the part of a family will see a thirty or forty foot dam raised two feet or more.

Ponds are often abandoned because the supply of food trees has become exhausted. After a new crop has grown the beavers may return and repair the dam and reestablish the colony, but very likely the newcomers may be entirely unrelated to the previous residents.

Dugmore says that spillways are often made on dams to take care of the overflow, though I have never seen anything of the sort myself. He mentions an instance of a dam under construction being threatened by a flood. The beavers made a large enough opening in the dam to permit the flood

waters to escape, and after the storm had passed and the water subsided they closed the gap and completed the dam.

Morgan distinguished two types of dams, the "stick dam" and the "solid bank dam;" the former of interlaced stick and pole work on the lower face, with mud and earth on the water or upper face; the latter usually found lower down on streams and containing much more earth and mud, probably much older structures than the first. Personally I have never been able to make any such distinctions. He thought curvature of dams was purely accidental.

He estimated the amount of material in Grass Lake dam, which was 260 feet 10 inches long, greatest height 6 feet 2 inches, to be upwards of 7,000 cubic feet.

Morgan knew of no instance in the area studied by him of a dam being constructed across a stream having a greater depth than two feet at the lowest water level.

Practically all dam building is done in the fall, in preparation for winter.

Beavers will build dams wherever a supply of water can be had to make a pond, and where a supply of food is at hand. They will build them across the outlets of natural ponds in order to raise the water level. The greater number are built on running streams. The previously mentioned dam at Crescent Hill was seemingly built to hold the water from springs in the gulch above, which are now covered by the pond, for there was no visible water supply, though in the spring melting snow must supply considerable water for a short time. On Tower Creek, also in Yellowstone Park, an extensive series of ponds utilized the water from a large spring on the creek bottom some distance away from the stream, and at the foot of the mountainside which rises above the creek valley. There were other series of ponds on the same stream which obtained their water supply in the same manner from other springs. The stream itself

was really too rapid and rough to be favorable for dam building, though I saw where the beavers were beginning one and had the foundation laid part way across. This had disappeared two years later.

Perhaps the most peculiar location for a dam which has come to my notice is one that I was told about. A number of years ago my informant had occasion to visit a mining tunnel on a mountain several miles southwesterly from Colorado Springs. This mountain, while of no great elevation itself, is much higher than the region immediately surrounding it. The tunnel was near the top of the mountain, and was about one-hundred and fifty feet long. The first twenty-five feet was in earth, and had been timbered with posts and caps, with lagging overhead and part way down the sides to hold up the ground. Aspen trees grew all about, evidently the attraction for the beavers. There was a good spring at the tunnel and the latter was wet, with enough water dripping from the roof to make a small stream which flowed from the mouth. All the water disappeared in the ground a couple of hundred feet or so below the tunnel dump.

Beavers had built a circular dam about ten feet from the mouth of the tunnel in such a fashion as to impound the water from both the spring and the tunnel. The dam was about eighteen inches high, built of mud, aspen sticks and brush, and backed the water up in the tunnel for some distance. Inside the tunnel holes had been dug in the earth at the sides of the timbered portion, and the earth from them apparently used in the dam.

Many peeled aspen sticks were in the pond formed by this dam, and at the breast of the tunnel were more. The bark had been pulled from these last in strips, and used to make a nest or bed, which was about four feet in diameter and three high. It was hollowed out on top.

While no beavers were there at the time of the examination the work looked fresh, and certainly had been done within a year. The visit was made in early autumn and the tunnel had been worked the preceding fall. The nearest stream is four or five miles away and that not suitable for beavers.

On Carnelian Creek in Yellowstone Park the beavers had done an interesting piece of engineering. On the flat on the left bank was a series of four good-sized ponds, which received their water supply from the creek in the following manner: An old dam, or its remains, extended part way across the stream, which was quite wide at this point, and which also made a considerable bend; from the end of this old dam an extension had been carried part way to the right bank in such a manner as to divert a portion of the stream into the upper pond, whence of course it went on down through the others. The creek had so much fall that the last of the ponds was several feet above its level (Fig. 18).

At times beavers drain the water from their ponds, either partially or entirely. Why, I do not know. Mills expressed the opinion that it might be for sanitary reasons, to permit the sun and air to purify the bottom of the pond and interior of the lodge, if one was present. Later the pond would be filled again by closing the opening in the dam. I know of one pond which was full in February, empty the following October (no visit made between those dates), and full again in November.

In the Yellowstone a pond with two good-sized lodges had been drained by a hole through the dam at the stream channel. The pond bottom was full of devious channels which, presumably, the former occupants had dug. The pond was apparently abandoned because all the aspens on either side had been harvested. The beavers were living in another pond a short distance upstream, and possibly in another below (Figs. 19 and 20).

UPPER: FIG. 18. THE DIVERSION DAM ON CARNELIAN CREEK
LOWER: FIG. 19. THE PONDS ON LOST CREEK, BEFORE DRAINING

FIG. 20. THE PONDS ON LOST CREEK, AFTER DRAINING

On another stream in the same region two connecting ponds were drained some time between July 23 and 28.

I have thought possibly the first mentioned pond had been drained to prevent the water in it from becoming stagnant before reaching the ponds below. Being of good size the current through it was slow and the water might need aërating. This theory, however, hardly seems applicable to the last mentioned ponds, where the conditions were quite different.

Beavers are frequently very bold when not molested, and will build their dams surprisingly close to inhabited houses, and even within the limits of a town. Several years ago a small dam was constructed in Ruxton Creek, in the town of Manitou, a thriving summer resort at the foot of Pikes Peak, with a permanent winter population of several thousand. One could look from the sidewalk down into the gulch where the stream was, and all along on the opposite side were houses. Even in the dull winter season people were constantly passing, yet the beavers had built this dam and had been cutting trees and bushes close by, even at the top of the bank close to the sidewalk (Fig. 21).

The following autumn a colony established itself on Fountain Creek, a mile below Manitou, not far, however, from houses, and built a dam near a railroad track, and cut down forty or more trees. This work was washed out by high water the following summer, and the animals moved upstream a short distance and built a new dam four feet high, under the bridge by which the railroad crossed the creek, making a pond one hundred feet long. They had felled a number of cottonwood trees here. I think these beavers moved away the following year and never returned (Fig. 22).

A somewhat remarkable instance is that of a couple of beavers which established themselves in an artificial lake at the summer resort of Green Mountain Falls, in the Ute

Pass, Colorado. To prevent the animals from destroying the few trees about the lake the townspeople carried green brush to them, which supplied food and also material for a lodge which they built beside an island in the lake. In 1926 they were still living there and had increased in number to four.

Such occurrences as the washing away of dams by floods are common happenings on our western streams, if not elsewhere. In the mountains these floods are usually due to melting snow in spring, which often raises a stream several feet above its ordinary level, and at lower altitudes cloud bursts in summer may send down large volumes of water at one time which tear out almost any obstructions which may be in their path. The floods in Colorado, in June, 1921, carried out every dam on a long stretch of one stream with which I am familiar, and changed the channel in many places. What the beavers did during the high water I do not know, but after the flood receded they evidently returned and built new dams, and there are still flourishing colonies on the stream.

Mills, speaking of the "Moraine Colony" at a time when it was deserted, said that the stream had cut deeply through the old main dam, and this showed that it had been built on top of an older and filled-up pond; this second dam was on top of a still older one. In the sediment of the oldest pond were found a spear head, charred logs, and a buffalo skull.

Dugmore says: "Agassiz, speaking of the age of beaver work, mentions the building of a milldam which required some excavating. 'This soil was found to be peat bog. A trench was dug into the peat 12 feet wide, by 1200 feet long, and 9 feet deep; all the way along this trench old stumps of trees were found at various depths, some still bearing marks of having been gnawed by beaver teeth'." By calculating the growth of the bog as about a foot a century there is

fairly good evidence that the dam built by the beavers must have existed about one thousand years ago.

USES OF DAMS

Beavers build dams for various reasons. The primary purpose for which one is made is to provide a sufficient depth of water in which the animals can move about in safety and to which they can retreat from their enemies, and in which they can transport their food supplies; deep enough to protect the entrances to the lodge, when there is a lodge, and the burrows in the banks. The pond must also be of such depth that when frozen in winter there will still be water enough to enable the inhabitants to move about under the ice and to provide a place for the winter storage of food. Such is a brief statement of the requirements of a pond intended for residential purposes.

But there are other uses to which a pond is put, and not every pond in a colony is inhabited by the beavers. They are often built to provide water in which food supplies may be floated to the main pond. Thus the "Deadwood Dam Pond" in the Moraine Colony near Longs Peak, described by Mills, was made to enable the builders to cut aspens in a grove on the shore of the pond and float them across, and thence carry them to the pond where they lived. This Deadwood Dam Pond was not on the stream but was filled by means of a canal dug for that purpose.

On a stream we often find dams above and below the main pond. These have several uses. All of them may be used for carrying food to the principal pond; those upstream from the latter are serviceable in controlling flood waters and preventing them from rushing in too great a volume into the latter and perhaps endangering it. Incidentally attention should be called to the fact that the whole series of beaver dams on a stream may be of great service to man in

preventing floods in the stream below them, holding back a surplus of water and permitting it to escape only gradually. These dams are of service not only for preventing floods, but also for storing water which may be used for irrigation.

The dam next below the main one is often, if not always, a protection to the latter by backing water up against its base, enabling it to resist increased pressures from water or ice. Of course all the dams of a series may protect one another in this manner.

Another use of beaver dams and ponds to man is that in those sections where canoes and light boats are used for travel sufficient water is found in the beaver ponds on streams where it might otherwise be impossible to proceed. Ponds and dams check silt coming down in the stream, and prevent it getting into reservoirs, ditches and fields farther down. One writer states that stock are now using several ranges in the National Forests of Colorado which formerly could not be used for lack of water. Beavers made ponds in the small streams, conserved the water, and made it available to stock during the summer. Beaver dams and flows along a stream often prove to be excellent firebreaks, preventing the spread of forest fires, which are checked by the flooded spaces.

A report of the Supervisor of the Gunnison National Forest, Colorado, gives an example of the value of beaver ponds as storage reservoirs. He says:

"During the protracted drought of the season just passed (1924), the water supply for the Minnesota reservoir ran low and it was evident that sufficient water for the late irrigation run would not be available. Fourteen large beaver ponds near the head of Deep Creek and just above the Minnesota canal were tapped and the water turned into the small stream bed and carried to the company's canal, thence to their reservoir, which was filled by this additional

UPPER: FIG. 21. BEAVER WORK IN THE TOWN OF MANITOU
LOWER: FIG. 22. BEAVER DAM UNDER A RAILROAD BRIDGE

UPPER: FIG. 23. POND WITH CONIFERS KILLED BY FLOODING
LOWER: FIG. 24. POND WITH ALDERS, ETC. KILLED BY FLOODING

supply. The president of the company stated that he estimated the value of this water to fruit growers along the Minnesota and North Fork valleys at not less than \$15,000, as it practically saved the fruit crop on every orchard that was depending on this irrigation project for water. This meant a little over \$1,000 for each of the fourteen dams tapped."

DAMAGE CAUSED BY BEAVERS

I have mentioned the uses of beaver dams, and it is only fair to look at the other side and say something about the damage caused by beavers. The damage to lands by flooding is probably slight as a rule, though sometimes western farmers complain of their meadows being flooded by beaver work (Figs. 23, 24 and 25).

Possibly the most serious damage is that caused to timber by flooding, of which Johnson has made a study in the Adirondacks, and this in spite of the complaints which were made, does not appear to be as serious as some of those opposed to the beavers claimed. It so happens that my own observations show comparatively little of this damage. While I have seen many trees thus killed, by far the greater portion have been aspens, alders and willows, which are not considered of any particular value. The commercial value of the pines, firs and spruces which I have seen destroyed by beaver ponds would be small, though they sometimes made a rather conspicuous showing when standing in a pond with their brown tops contrasting with the green living trees about them. Besides flooding there is also the damage which may be done by cutting down trees or girdling them, though this is little compared with that done by flooding.

Dr. C. E. Johnson has made what is probably the closest study of such damage with the object of arriving at some-

where near a correct estimate of the amount. This was in Hamilton and Herkimer counties of the Adirondacks, New York. He quotes from the New York Conservation Commission's report that in 1919 forest rangers estimated that 8,681 acres had been flooded by beavers in the Adirondacks, and the estimated value of merchantable timber thereon was \$51,425. In 1920 this damage had been increased by \$3,410, making a total of about \$55,000.

Johnson expresses the opinion that the damage to timber due to beavers is much less than that caused by windfalls and by fire, to say nothing of the waste by man in lumbering operations and otherwise.

The owners of private property in the Adirondacks, especially those having summer homes there, are those who most keenly feel the depredations of the beaver. This is naturally the case, considering that the destruction of the trees results in marring the beauty of their property. Where beavers are near houses they may do harm by cutting fruit or shade trees which have been planted. In a public park in Colorado Springs wandering beavers occasionally cut some of the shade trees and shrubs. These beavers apparently come down a stream which flows through the park, enter one of the ponds, of which there are several in the park, and of course do some tree cutting in order to obtain food.

Dugmore considered that the damage to timber by beavers is hardly worth mentioning. In this connection, Fins, Feathers, and Fur, the Bulletin of the Minnesota State Game and Fish Department, says some small timber is killed by beavers as a result of the flooding of low lands, but usually this is not of great value, and the damage is not extensive. This Bulletin agrees with Johnson that losses by wasteful lumbering, forest fires, and attacks by insects are far greater than those caused by beavers.

It has been claimed that deer die of thirst in the Adirondacks in winter because they can find no open water where they can drink, the beavers damming the streams so that they freeze entirely over. The deer eat snow for a while but finally give up. It is stated that forest rangers have found deer that have thus died.

CHAPTER V

THE LODGE

The beaver's lodge, house, or hut, is the second of those structures which have given the animal a reputation as a builder. The image which usually forms in a person's mind when one is mentioned is that of a beehive-shaped affair standing in the pond away from the shore, entirely surrounded by the water. While this is the common form, it is not the only one. There are all gradations from it, from that built in the water, with one side against the bank, to the one partly in the water and partly in the bank, and finally we have the lodge wholly in the bank away from the water, sometimes several feet. The latter are called "bank lodges," while Morgan called the first kind "island lodges." They intergrade so that it is impossible to draw a hard and fast line between them (Fig. 26).

It seems to me that probably the bank lodge was the first structure of the sort, and that the island lodge evolved from that. Just which variation of the bank lodge was the first to appear one can only guess. There are arguments in favor of each, and it seems quite probable that ancestors of our present day beavers may have begun building lodges of the different types in separate localities, and independently of one another, and that the habit gradually spread to all the beavers, with the consequent adoption of all the variations. Not all beavers build houses. Some never do, but live in burrows in the banks of streams and lakes. Of these burrows more will be said later. Others may sometimes live in lodges, and at other times in burrows, according to circumstances, and as a matter of fact, I doubt if, even when

UPPER: FIG. 25. POND WITH WILLOWS, ETC. KILLED BY FLOODING

LOWER: FIG. 26. A TYPICAL BEAVER HOUSE

UPPER: FIG. 27. INTERIOR OF THE LODGE ON LOST CREEK

LOWER: FIG. 28. DRAINED POND ON LOST CREEK, SHOWING THE LODGE

the animals have lodges, they are ever without burrows in the banks of the pond whenever it is practicable to make them, these being used as places of refuge.

The island lodge, being the best known, and, after all, being regarded as the type of these structures, will be described first. The typical lodge of this sort is a round, conical or beehive-shaped structure of mud and sticks in the pond at varying distances from the shore, sometimes but a step or two, and again many feet. It has a solid foundation of some sort, a small natural island, a shallow spot in the pond which gives an opportunity to begin building, or the beavers may make a foundation by carrying mud and brush to the desired spot, or more likely digging the former up from the bottom around the chosen spot and depositing it where needed. The house is built by piling mud and brush upon the foundation.

Beavers are bound by no hard and fast rules in building their houses. Their sticks do not have to be laid just so, and trued and plumbed so that the building will not fall down. Nothing of the sort. They lay the sticks across one another in any way convenient, piling mud on them as they go along, only taking care that little or no mud is put in the middle, so that an air space is left between the sticks. This is their ventilator.

The entrances are begun deep enough below the surface of the water to be safe from freezing. They are made by burrowing up from or near the bottom of the pond, gnawing off the ends of the sticks which interfere, and when above the water level making the living-room or chamber by a continuation of the process, forming a space suited to the size of the family. Dugmore says there are two 'floors, one a few inches lower than that of the main room, and this is the one on which the occupants come up from the pond, and where they stop to permit the water to drain from their bodies, thus

keeping the sleeping room dry. I have not happened to run across any arrangement which conformed exactly to this description.

It was my good fortune, however, to find a lodge in a drained pond on Lost Creek, Yellowstone Park, which had one entrance so large that I could enter the house without having to destroy any part of it for the purpose. The outside dimensions of the house were about $13\frac{1}{2}$ by $16\frac{1}{2}$ feet

FIG. 29. FLOOR PLAN OF THE LODGE ON LOST CREEK

on the bottom, and about seven feet high. The owners evidently believed in preparedness, for they had no less than eight doors or entrances, all at the pond bottom. Nor did they think it wise to have them all come to the interior at the same place. The diagram shows how they arranged matters. One came up through the floor of the living-room, possibly for a sudden departure in case an unwelcome caller arrived. Another, opening outside near the above, passed clear under the chamber, and came out on the first floor or

level. This latter was about a foot above the pond bottom, and eighteen inches below the chamber floor. No doubt it was under water when the pond was filled, so could not serve any of the purposes Dugmore mentions (Figs. 27, 28 and 29).

The entrance by which I gained access to the interior was forty-two inches wide—wider than many a front door in our own houses. Why it had such a width I do not know, but it showed no evidence of having been widened by any animal intruder. On either side of and above it could be seen the ends of the sticks of which the house was built, all showing the marks of the builders' teeth made in cutting them off. These sticks were from less than an inch up to over three inches in diameter, and many appeared to have had the bark eaten from them before being used as building material. Thus they served a double purpose.

The first floor was two feet wide and four feet long. The living-room was of a somewhat triangular shape, six feet in its greatest length and width, and eighteen inches high. It also showed the cut-off ends of sticks all about its interior, with mud between them. The occupants had either dispensed with bedding or taken it with them when they moved. None was found. Flash powder was burned in an attempt to photograph the interior, and the smoke poured freely from the top, showing good ventilation, no doubt better than when the house was surrounded by water, cutting off the draft. A beaver has low respiration and circulation, and does not need as much air as some other animals.

The chamber was of such size that a man could get into it, and did. In fact, two of us did so. It was said that John Colter, the first white man to visit the Yellowstone Park, was once pursued by Indians, and escaped by diving into the water and entering a beaver lodge. The house just described shows that the story is not improbable, and it was not an unusually large house.

appeared to be such, most of them being at the pond bottom. On our first visit we crawled into one which was eighteen inches above the bottom, and succeeded in getting in far enough to discover that it branched into two passages or rooms. Returning a few days later with tools this entrance was converted into an open cut extending to the point where the rooms separated. Here the log barred further progress. I could, however, wriggle into the rooms, and obtained sufficient data to make the accompanying plan. The rooms were scarcely a foot high, and I had to lie flat on either my back or abdomen to make the necessary measurements. Returning a few days after this I found the roof had settled so much that it was impossible to get in. The house was evidently an old one and the sticks composing it were very much decayed. A long wire introduced into the various entrances always came against some obstruction which interfered with its further progress (Figs. 30 and 31).

From the size of the lodge we expected larger chambers or more of them. As the plan shows, there was space for another room south of that found on that side, and one may have been there. There were trails over the top of the house, and in the right hand room were found porcupine quills and dung. Woodchucks or marmots also frequented the place, sunning themselves on the top.

The first lodge which I ever opened was in Colorado. This was built of willow brush mixed with mud. It was easily cut across with an axe so as to expose the room. This lodge had been abandoned for some time. Before opening it measured ten feet across from east to west, and eight feet across the section from north to south, along the line where the cutting was done. The room was two feet wide and extended back $4\frac{1}{2}$ feet. It was ten inches high, but the roof had undoubtedly settled. The latter was twenty-two inches thick, and the walls on either side three

feet thick. The floor appeared to have been just above the water level, and had a bed of coarse swamp grass on it. The single entrance which I discovered came into the room from under a mass of brush which lay to the east of the house, and extended a distance of fifteen feet out from the latter. This brush had been stored there as winter food, and never used. It was a very efficient vestibule to the front door, and doubtless afforded protection to the animals when they entered the lodge (Figs. 32 and 33).

Audubon said that a lodge examined by him had an entrance $2\frac{1}{2}$ feet in diameter, through which three of his companions entered but found nothing. He gives no other details as to the size of the lodge.

Dugmore says that of the two levels he mentions the inhabitants enter on the lower and remain to permit the water to drain from their fur and to dry themselves. On the second floor, a few inches higher, is the bedding material. The lower floor is also supposed to be a dining-room. He gives the interior dimensions of one house as: 4 feet 10 inches long; 4 feet 5 inches wide; 2 feet 1 inch high; lower floor 4 inches above water; bed floor 6 inches higher. He also says that some of the interiors may be as much as twelve feet in diameter. This seems very possible, for in the case of the large lodges mentioned by him and Johnson, and the one on Tower Creek, allowing but six feet thickness for the walls on either side, which seems to me more than ample, there would still be left 25, 23, and 27 feet for the respective greatest lengths of the rooms inside, that is, supposing there to be but one room to the lodge. These large lodges often have two or more unconnected rooms, and all the lodges which I have opened had irregularly shaped chambers.

Morgan opened a lodge the outside measurements of which were 16 feet 4 inches by 19 feet 9 inches; height 4 feet 6 inches above waterline; chamber 7 feet by 7 feet 8

FIG. 31. OPEN CUT INTO THE LODGE ON THE PETRIFIED TREE ROAD

UPPER: FIG. 32. A LODGE IN COLORADO BEFORE CUTTING OPEN

LOWER: FIG. 33. A LODGE IN COLORADO AFTER CUTTING OPEN

inches; height of chamber 1 foot to 1 foot 4 inches. Size of entrances through floor 15 inches square, and length of entrances 7 and 10 feet.

A used lodge on the margin of a slough near Palo Verde, on the Colorado Desert, in southeastern California, not far from the Colorado River, was opened. It was three feet high and twelve feet across the base, built of branches and small saplings cut when in full leaf, by the beavers and laid compactly. It was eight inches thick over the nest cavity. The chamber was $2\frac{1}{2}$ feet high by four to five feet across. "At one side the bank had been cut away to make the floor comparatively level, as the house was built on a sloping bank near its top. There was an underwater entrance at one side, and an opening through the wall above ground. A fresh willow sapling had been hauled through this opening butt first. The beds were merely hollows in the earth floor."¹

In the good old days when fiction had precedence over fact in writing about the beaver, it was said that some lodges were divided into several rooms, for eating, sleeping, store-rooms, and the like, but of course such is not the case. Hearne says concerning this: "It frequently happens that some of the large houses are found to have one or more partitions, if they deserve that appellation; but that is no more than a part of the main building, left by the sagacity of the beaver to support the roof. On such occasions, it is common for these different apartments, as some are pleased to call them, to have no communication with each other but by water; so that in fact they may be called double or treble houses, rather than different apartments of the same house. I have seen a large beaver house built in a small island, that had nearly a dozen apartments under one roof; and, two or three of these only excepted, none had any communication

¹ Grinnell, *Birds and Mammals of the Colorado Valley*, p. 226.

with each other but by water. As there were beaver enough to inhabit each apartment it is more than probable that each family knew its own and always entered at its own door."

Hearne said that his Indians took thirty-seven beavers from this house, and many others escaped. His observations were made in the latter third of the eighteenth century.

A lodge is usually small at first, and grows by additions to the outside and enlarging the chamber as these additions are made. Just how separate rooms are made I do not know, though I have had a hint as to one possible method. In 1921 a small lodge and a larger one stood close together in a pond on Lost Creek. In 1923 the two apparently had been merged, and it would seem probable that here the two rooms were kept separate.

Morgan states that the number of lodges in a pond rarely exceeds four, though in some cases six and eight have been found. I have never seen more than three in a pond myself.

Good-sized logs and poles are often, if not usually, placed on the top of a lodge, presumably for protection. It is a favorite place for leaving sticks after the bark has been eaten from them. Dugmore speaks of logs eighteen feet long and six inches through at the butt as often used, but I have never seen any of such a size. He also says that shorter pieces a foot or more long are not uncommon. I have at times seen poles ten or twelve feet long on houses. Perhaps this heavy stuff may be of service in weighting and holding down the exterior materials of the house.

It is essential that there be water about the lodge sufficiently deep to protect the entrance from freezing. Often this is provided by the animals in excavating the material to build their home, and perhaps sometimes for a dam. This deep water is also often used for storing the winter supply of food.

In autumn the lodges are usually plastered well with fresh

mud, at least in those regions where there is severe cold. Hearne makes a statement to this effect concerning the beavers in northwestern Canada. Mills gives the statistics of lodges of which he made notes in Colorado and Montana, and these show that the great majority were well plastered before the coming of winter. Dugmore also makes statements to the same effect. Without keeping any special notes on this point I also have noticed the occupied lodges usually are plastered in October. Morgan says that *in some cases* the outside of the lodge is plastered with mud late in the fall.

I have never seen any data as to how long it takes to build a lodge. The only note I have bearing on the subject is of a pond which had no lodge in it on August third, and on September third there was a small one with a heap of brush in the water beside it.

A house is often built about a bunch or clump of bushes or small trees, such as willows or alders, which frequently have several stems growing from one root. The roots evidently furnish the necessary foundation for the lodge, the building material being piled upon them and about the stems of the brush, which, when outside the confines of the cavity, often continue to grow and bear leaves. A somewhat unusual example of this kind was a lodge in the Longs Peak region, Colorado, which had no less than sixteen living alder trunks coming up through the outer portion, ranging from $2\frac{1}{2}$ to 5 inches through, being evidently outside the boundaries of the chamber.

Another lodge which I saw in the same region had a lodge-pole pine standing in the center, and the structure was obviously built about it. Being out in the pond it was inaccessible to me and I could not make a close examination. Though dead, the pine still had brown needles on its branches. I was told that the house had been built four or five years previously (Fig. 34).

Frequently, if not always, lodges have smooth slides or trails from their tops down to the water. They have the appearance of being used for sliding only, as they are smooth mud and lacking in footmarks or other indications that the animals have climbed up them. Presumably the beavers make the ascent elsewhere on the house and descend over the slides, a speedy way of getting down if an enemy appears. Perhaps they do it just for fun, as an otter does on its slides.

Lodges naturally vary much in size. Some are small. I have seen one only six feet in diameter, while others very much larger exist. In 1921 a lodge on Tower Creek was 21 by 24 feet, and 7 feet 3 inches above water level. In 1923 the same lodge was found to be $33\frac{1}{2}$ by 39 feet at the water level, the largest of which I have any record. It was then $6\frac{1}{2}$ feet high. Possibly the top may have settled, but I think the water level in the pond had been raised. The house had five entrances in 1921. Dugmore mentions one in Newfoundland which was 37 feet in its greatest diameter, and Johnson gives a picture of one in the Adirondacks 35 feet in its greatest diameter and 28 feet in the shortest, and 7 feet high. A house in Gunnison County, Colorado, was of an oval shape, 17 by 22 feet on the ground, and 12 feet along the ridge on top.

The number of inhabitants to a lodge of course varies; the normal beaver family consists of two adults, the young of the year, and the young of the preceding year, or kits and yearlings, as we may call them. Morgan says the Lake Superior trappers estimated seven to the lodge, and the Rocky Mountain trappers eight; this was in the middle of the eighteen sixties. Johnson based his estimate of the number of Adirondack beavers on ten to the lodge. I noted eight living in one lodge in Yellowstone Park.

The bedding material may be either grass or shredded

wood. Dugmore says the latter is more frequently used, and that may be the case where wood is easily obtainable, but many beavers live where there are only small willows or other bushes and are practically forced to use grass.

The following remarkable description of beaver lodges is taken from *Fauna Americana*, by Richard Harlan, published in Philadelphia in 1825:

“The huts are established on these dams, and formed of nearly the same material as the dikes; the huts are two stories high, each story eighteen inches in height; logs composing these cells have been observed two feet in length, sixteen inches in circumference, and weighing fourteen pounds; it is evident from the marks on the ends of these logs, that they have all been cut through with the teeth, and notched at the end, so as to interlock with each other in the same manner as logs fashioned by human industry for the purpose of constructing the common log houses. The base of the lower chamber is under water, as is also the hole by which they enter.”

An old book in which is what purports to be an account of the beaver has a picture of a lodge with doors and windows in it, quite like a real house.

BANK LODGES

As I have already remarked, bank lodges vary in the manner of their construction. Some are built wholly outside the bank, but against it; others partly outside and partly in the bank; and still others wholly in the bank, perhaps several feet away from the water. One can not help wondering which type was the first to be developed from the burrow, undoubtedly the primitive habitation of the beaver. Perhaps it was the last named, for it would be a simple matter, if the ground above a burrow happened to cave in, for the owners to pile sticks and earth over the opening, enlarge the chamber if necessary, and they would have a lodge.

The lodges built against the bank, of either sort, are probably also a development of the burrow, originally begun by placing sticks in the water before the entrance as a protection, and afterwards developing these accumulations into houses. Even now one not infrequently sees small piles of sticks before the entrances to burrows, and it may have been from such as these that bank lodges originated, and later the island lodge. Morgan speaks of burrows on the Upper Missouri as protected by a "false lodge," evidently just such piles of sticks as I have just mentioned. In some cases the winter store of food may possibly be placed at the burrows, and also the discarded sticks may accumulate there.

Shiras² speaks of locating a beaver burrow deep within a bank by a lake. "The next year it broke through the surface soil, which was then covered with a mass of sticks." Such occurrences as this might well have been the beginnings of bank lodges, at least of the kind in the bank away from the water. It seems very likely that where the bank is not high enough to permit of the excavation of a chamber sufficiently elevated above the water level, the opening is made to the surface and then covered with brush and mud, or possibly the covering may be put on first and then the earth removed from below. There are many things of this sort which we have yet to learn about the beaver.

An abandoned bank lodge in the Yellowstone Park was built over a burrow, beginning close to the old shoreline of the pond. It was twelve feet long, six wide, and the highest part $5\frac{1}{2}$ feet above the bottom. The burrow continued into the hill back of the lodge. This consisted of sticks piled over the burrow, mixed with the usual mud. The burrow must have been widened to make a room, but the affair was so old that not much could be learned about it.

² Wild Life of Lake Superior, p. 196.

UPPER: FIG. 34. THE PINE TREE LODGE
LOWER: FIG. 35. A BANK LODGE, CARNELIAN CREEK

FIG. 36. A LODGE AFTER THE SNOW CAME

A bank lodge at a pond by the Cooke City road had a cavity extending into the bank. This was divided into two parts by a large rock. The longer portion was some six or eight feet long, two wide, and a foot high. The other was about two feet shorter. There was some shredded bark on the bottom of the longer cavity, apparently the bedding (Fig. 37).

I examined two abandoned bank lodges on the same stream in Colorado, each of which had the living-room just below the surface of the ground. These had each been a foot or more high and covered with a roof of sticks a foot or more in thickness. Owing to age this had settled so that the original thickness could not be told. Each of these lodges was several feet from the stream bank.

H. A. English, in a letter, describes a beaver house which he found in Saskatchewan, Canada, and which seems to show that at times the beavers may make very serious mistakes in locating their lodges. It was in a long, narrow muskeg. There was no open water, and while it was muskeg, grass and moss grew all about the lodge, and the animals had dug canals to willow thickets about sixty yards from it. "In thinking it over I am unable to see how the beaver got their food or kept the passages open. . . . I have never before or since seen a lodge which looked more out of place. . . . It was November and of course there was heavy ice on lakes and creeks. I would not like to say the beaver were in the lodge, but think they were, in which case they might starve or come out very poor, where they are usually very fat and sleek. . . . While trapping in Manitoba I have come across muskrat houses that were built in shallow water and the rats had been able to keep a very limited space from freezing and were very poor and nearly starved, while rats that had their houses in the same marsh but in deep water were fat and prime."

G. B. Grinnell, in "The Cheyenne Indians," tells an

interesting story of some Indian children entering what apparently was a bank lodge. Three little girls, ten or twelve years old, were sent to the river by their mothers to get water. When they reached the stream they decided to take a swim before returning. Removing their clothes they went out on a fallen tree projecting over the water. One of them noticed a hole in the bank under water and suggested they see where it went, so they dived and swam under water up the hole. They felt something large and soft pass by them, going out. A beaver, of course. They went a few feet and saw a little light, and discovered they were inside a beaver house. A little frightened by the beaver which had passed them as they were going in, they did not dare go back, and therefore broke a hole in the roof where the light came in, and emerged from this. They found themselves in a thicket of wild rose bushes and were much scratched before they made their way through them.

BURROWS

The beaver was perhaps naturally a burrowing animal from the very beginning; at any rate, it still is, and as before remarked, many beavers never build houses but live in burrows in the banks of streams and lakes. In many cases a stream may be too rough or swift for a dam to be built, or so wide and deep as to be beyond the beaver's engineering skill, and yet have a plentiful food supply upon its banks, and here the animals make their homes in holes. In such cases they are called "bank beaver" and are often said to be a different sort from those living in lodges. Such is not the case, however. They are merely adapting themselves to circumstances, and, as a matter of fact, the lodge builders usually, if not always, have burrows in the banks of their ponds in which they can take refuge if disturbed in their houses, or if pursued by an enemy and unable to reach the lodge. On a

little stream in the Yellowstone a lodge in one pond was inhabited by a family of eight beavers, and three others were living in a burrow a few ponds below. It is said that the male beaver, as the time approaches for the annual addition to his family, removes to a burrow and remains there several weeks.

I have been unable to obtain much information as to the length of burrows. One which I examined in the Yellowstone had a total length of thirty feet, but that struck me as unusual, though Bailey says they are sometimes forty to fifty feet long, and large enough for a man to crawl into. Various burrows examined by Morgan terminated under the roots of trees. Those which he described were from ten to over thirteen feet long, some leading from ponds, and one from a canal. He gives a diagram of the latter showing at the end a chamber 2 feet 6 inches by 3 feet 2 inches, and about ten inches high. "The roof of the latter came near to the surface, and was formed chiefly of the roots of the clump of trees under which it was excavated."

CHAPTER VI

CANALS, TRAILS, AND LANDING PLACES

CANALS

The canal is the third of the structures of the beavers which have made them noted among four-footed animals. It is the least known, though the one which might, in many respects, be considered as showing the most intelligence on the part of the builders. Not that they do not make mistakes at times, and dig canals which fail to carry the water where desired. Sometimes an engineer of the genus *Homo* surveys a ditch in which the water will not run! Whether guided by intelligence or by a highly specialized instinct the beaver does construct some remarkable works in the form of canals. Morgan very well says that the canal of itself is simpler than the dam to construct, but requires more intelligence to plan.

The ordinary canal is built for the purpose of transporting logs from the place where they were cut to the pond, and also to afford a water way in which the builders may pass back and forth in more security than when traveling on land. Morgan gives an instance where beavers cut a canal across a narrow neck of land to save going around a bend in the stream, this being purely for the purpose of traveling and not for transport.

Canals vary much in length, from those but a few feet long, hardly worthy of the name, to those several hundred feet long, and built with two or more levels in them, the first or lowest being the only one to receive water from the pond or stream, the upper ones getting their supply from a

spring or stream at a higher elevation, or, as in the case of some examined on Tower Creek, from the swampy ground in which the upper levels were dug. One of these was ninety feet long, the other one hundred and fifty feet, and they represented somewhat different engineering problems. The first mentioned was seventeen feet long at the pond level to the lower side of the dam, and twenty-three feet to the upper side, and above this was the remainder of the ditch. The lower level of course obtained its water from the pond and was fifteen inches deep; the upper level was nine inches deep and was supplied by seepage from the marshy ground about it. The canal varied in width from fifteen to eighteen inches. The face of the dam had a long gradual slope which must have greatly facilitated dragging logs over it. Aspens were being cut on the hillside above this canal.

The second canal was about half a mile upstream from the other, and its lower end was twenty-three feet away from the creek, being connected with it by a trail, and at the time of the examination this was two feet above the water level. There was but one level to the canal, which was from three to four feet wide, and twelve to eighteen inches deep, the water supply being derived from a spring at the landward end. The westerly bank of this canal was considerably lower than the other and was being raised by means of mud dug from the bottom. Aspens were being cut near the end of this canal (Fig. 38).

Morgan described one canal 523 feet long leading from a natural pond, 450 feet from which was a short dam across the canal; 25 feet above that was another dam extending 27 feet on one side and 75 feet on the other side of the ditch; and 47 feet farther up, at the head of the canal, was a third dam 55 feet long on one side of the ditch and 87 feet on the other. There were pools of water above the head of the canal, and the long dams collected the drainage from these

and deflected it into the canal, besides collecting the rainfall and using that. This canal was from two to four feet wide, and $1\frac{1}{2}$ to $2\frac{1}{2}$ feet deep, the greater portion being of the first named width. The first 450 feet was cut through level ground and received water from the pond.

Another canal from the same pond divided into two branches at the end of 150 feet, these being 100 and 115 feet long respectively, and extending along ground covered with deciduous trees, giving access to a large food supply, for which water transportation was thus furnished. This ditch was from three to five feet wide and eighteen inches deep. It had several burrows dug from it under knolls covered with trees, apparently for refuges.

Morgan also describes another three level canal from the Carp River which was 579 feet long, 3 to $4\frac{1}{2}$ feet wide, $1\frac{1}{2}$ to $2\frac{1}{2}$ feet deep. The first dam was 111 feet from the river, the second 289 feet. The ground all about was swampy and the ditch was filled by filtration from this. At the mouth of the canal the river was not deep enough for a beaver to swim below the surface out into the stream, so the beavers dug a channel twenty-five feet long and a foot deep in the river bed, giving the desired depth.

In the region described by Morgan tamarack trees were nearest the water and on quite level ground. The deciduous trees desired as food were farther back, and therefore the beavers were obliged to make these canals in order to reach them.

If I have been somewhat tedious in going into all these details and figures it is because I wished to show the remarkable nature and what we may call the magnitude of the work thus done by the beaver, for surely these long canals deserve the term when we consider the tools with which they are made. The two and three level canals are of course the most remarkable. It is easy enough and natural to dig a

ditch at the pond level so that the water will fill it, but quite another thing to make one at a level above this and build a dam to retain the water derived from some other source, and thus avoid digging the pond level portion to an impracticable depth.

Speaking of a certain canal Mills says that the mud dug out in making it was piled evenly along the lower side, and looked more like the work of a careful man with a shovel than of beavers without tools. He also mentions a canal begun at the Moraine colony and then abandoned because the beavers discovered they could not make it carry the water where they wished. He describes a series of canals dug in the bed of Lily Lake, Estes Park, at a time when the water had fallen so low that there was not sufficient left for the use of the beavers. It finally receded so much that the only water left was in the ditches, which must have been the work of years. For a detailed description I refer my readers to his book. It must suffice to say here that these canals varied in length from quite short ones up to one 750 feet long. Mills states that he has known of beavers extending canals in the bottom of a pond and making submarine tunnels when the pond was ice-covered.

In another book,¹ describing the struggle of a colony for existence during winter, Mills states that a ditch two feet wide and nearly as deep was dug from the house in the center of the pond to the upper portion, which had been swampy before being flooded, and where they were able to secure enough roots of various sorts to ward off starvation. This was, of course, after ice had covered the pond.

Mr. Mills called my attention to a canal on the Roaring Fork which differed from the usual type in having a very steep grade. The beavers were harvesting aspens some

¹ *Famine in Beaver Land, in Watched by Wild Animals.*

distance upstream from their pond, and found difficulty in floating the logs down the bouldery creek bed at the then low water stage. Therefore they went off a little distance to one side of the stream, and taking water from a pond there above the bad water, led it down so that it rejoined the creek at a pond below the rough places, much simplifying the transportation problem. It is not clear to me just how much ditch was actually constructed, but I think probably only enough to start the water on the right course, for the slope down which it flowed was steep enough for the water to cut its own channel easily. To do this certainly showed good sense on the part of the animals, for in attempting to use the stream one or two of their number had been killed by a mountain lion, and they had been able to get only a few logs down after much labor.

S. Stillman Berry has given an account of a beaver canal in Montana which seems to be the longest on record. A portion of it was carried through a slough, or perhaps it would be better to say that the builders utilized the slough as part of the canal, though they seem to have done some bank building in it to confine the water. A portion of the canal was cut through a swampy place and the mud thrown up on either side to make the banks. The length of the waterway was 745 feet, and the total length of the whole stretch used for conveying logs, including a waterless section at the further end, 1145 feet.

Dugmore states that the canals are completed before wood-cutting operations are begun. But this would be true in only a limited sense, for the very long canals I have mentioned were doubtless constructed by degrees, extended as became necessary to reach additional supplies of food.

Seton says the longest canal he ever examined was an old one in the Adirondacks, which was 654 feet long, and nearly four feet wide. It was well marked after fifty years of abandonment.

UPPER: FIG. 38. A CANAL, TOWER CREEK

LOWER: FIG. 37. A BANK LODGE, COOKE CITY ROAD

FIG. 39. A BEAVER TRAIL PASSING UNDER SEVERAL DEAD LOGS

In studying some beaver work on a stream in Colorado where the food supply was small willows, which grew thickly over the bottom land, I was quite surprised to find several canals leading from various of the ponds out among the willows, being from fifty to nearly a hundred feet long. The beavers apparently found it advantageous to have water transportation even for willow brush. Trails led from two of these canals across to another pond a short distance away, on a side channel from the creek, indicating that probably the canals were also used for traveling.

On the South Fork of Elk Creek, not far from Yancey's, was a canal leading northwesterly from the end of the lowest pond of the series, which was 104 feet long, 4 to 6 feet wide, and 27 inches deep. The material dug from this was thrown up on the lower or northeasterly side. Two years later this canal was found to be abandoned. From another pond in the same group a ditch extended 48 feet. It was a foot wide, and the first 27 feet were 18 inches deep, while the remaining portion was merely a shallow run, at the end of which was a dam extending 20 feet in an easterly direction from the ditch. The pond formed by this dam was only about six feet wide, into which a mere trickle of water came, also a trail. The purpose of this dam was probably to collect and conserve whatever water drained or seeped in from above so that it might be conveyed by the canal to the pond below. In summer, at the time of my visit, there did not seem to be much tree cutting going on at this place.

At another colony in the Yellowstone some of the smaller ponds of the series were connected by canals thirty to forty feet long, sixteen to eighteen inches wide, and eight to fourteen inches deep, leading from below the dam of one pond down to the next, and invariably there was a trail and slide over the dam into the canal, showing evidence of constant use in traveling back and forth, and probably for carrying logs.

Dugmore suggests that canals may have had their origin in the use of short natural openings in the shore of a pond, which were gradually extended, and finally the beavers learned to build canals wherever they wished, if feasible.

It will be seen from the foregoing that there are many variations in the construction of canals, and some in their uses. Not all colonies have canals, for of course they are not always necessary, but when made they are adapted to their intended purposes, whether to bring logs some distance from the pond, or to serve as a connection between two ponds. They are so notable that one can not refrain from expressing surprise at such things being done by animals having no tools but their fore paws, and the mental faculties of which, according to some, are no more than a highly specialized instinct.

TRAILS AND LANDING PLACES

In pursuing their activities on shore, beavers often make well defined paths or trails, which, when in use for a considerable length of time, may become deeply worn. As many, if not all the trails, are used by the beavers in carrying logs and brush, this material is probably responsible for most of the cutting down of the path. While I think it somewhat doubtful if the animals really lay out a road and clear it before beginning to use it, though some have stated that such is the case, they do cut out any roots, branches or logs which may interfere with their work. I have seen a four inch stick which had been cut through and part of it pulled to one side of a trail. Rotten logs lying across a trail are broken and worn by the sticks dragged over them. Conversely, trails sometimes pass under fallen logs which are lying high enough above ground not to interfere with the beaver going beneath. I saw one trail which went under eight logs in a distance of twenty feet (Fig. 39). Johnson

FIG. 40. A LANDING PLACE

LEFT: FIG. 42. A BEAVER'S TRACKS IN THE MUD. THE SHAPE OF THE HIND FOOT IS VERY WELL SHOWN

RIGHT: FIG. 41. A LANDING PLACE

FIG. 43. A BEAVER TRAIL SHOWING WHERE LOGS HAVE BEEN DRAGGED
OVER IT

FIG. 44. A BEAVER TRAIL IN THE SNOW

figures a trail, or "tote road" as he calls it, cut through the crest of a bank in the Adirondacks about a hundred feet above the water.

Where there is, as is often the case, tall rank grass growing on the shore of a stream or pond, trails through it are decidedly noticeable. The beavers crush the grass down on the ground, and often bring mud out on their feet, making a very well defined road. Often at these trails a considerable space is trampled down on the shore, apparently where the beavers have landed. I have called such spots "landing places." From the fact that peeled sticks are often found at them they may be used as feeding places (Figs. 40 and 41).

Here may be mentioned the "forms" described by Johnson as seen by him in Minnesota. They were located close to the bank, so that the occupant could get into the water quickly, and were used by the beavers in the daytime, either as sunning or resting places. He says they were more or less shallow depressions in the ground, roughly oval in outline. Sometimes they had a little bedding, of either small chips or dry twigs and grass. As a rule they were free from peeled sticks. None of the places which I have examined myself answers this description, though I have seen a place where the grass was crushed down as if an animal had been lying there.

Many trails will show the marks where logs have been dragged over them, the end of the log having left a distinct furrow in the ground. In other cases where brush has been dragged alongside the beaver, the scratches made by the ends of the twigs are plainly visible. I have seen this not only in gravel and sand, but also in snow when it has fallen early in the season when the animals were still harvesting their winter food. The mark made by a log is somewhat similar to that made when a log is drawn over the ground by a man or horse (Fig. 43).

Seton, in his description of the beaver ponds near Yancey's, in the Yellowstone, mentions what he calls docks or landing places. These were short canals with raised mud or sod wharfs at the end. "These are either lookouts or sunning places." Usually there were paths leading away from them. At Yancey's, Seton says many short trails ended at anthills occupied by small black ants. He suggests the beavers may have gone to these to let the ants pick off parasites.

Paths are frequently found along streams which are detours around a rocky or steep portion of the channel avoiding rough traveling, and possibly are not necessarily used for transport. I have seen some which appeared to be much traveled and yet showed no indications of anything being dragged over them.

Beavers sometimes have underground passages from the bank, coming to the surface some distance from the shore. One was found in the Longs Peak region the exit of which is shown in the cut. This was some twenty feet from the bank of the stream. The grass about it was matted down and much covered with mud over a space $2\frac{1}{2}$ by 6 feet, and from the hole a trail led up the hill toward an aspen grove. This hole was 54 inches long by 26 inches in greatest width (Fig. 45).

CHAPTER VII

BEAVER MEADOWS

Beaver meadows have played a very important part in the development of North America from the earliest days of its settlement. This is because they provided level land, good soil, usually covered with grass, sometimes also with bushes. The grass provided pasturage and hay, and the meadows, when cultivated, produced good crops, so that it was but natural that when available these were the first lands to be taken.

"Fins, Feathers and Fur" says "Most of the forest meadows where the pioneer settler is able to obtain hay for his stock have been caused by the killing off of small timber by beaver flooding many years ago, and in this way the beaver have contributed to the convenience of the farmer."

While presumably the above quotation is intended to apply especially to present conditions in Minnesota, doubtless it is also applicable to the conditions found by the earliest settlers in the Atlantic States, who must gladly have availed themselves of any open spaces which did not involve clearing the timber from the land.

Building the dam can well be said to be the first step taken toward making a beaver meadow, for as soon as the pond is made silt begins to settle in it and fill it. This forces the owners, as explained in the chapters on the dam, to continue raising the dam to keep the water deep enough for their purposes. The filling-in process continues indefinitely, but a pond never becomes a meadow as long as the beavers continue to occupy it. Let them abandon it, however, and a meadow may be formed in a surprisingly short time.

It has not been easy to obtain any definite information as to the length of time required to form a beaver meadow, and we are fortunate in having some data concerning the meadow on Lost Creek, above Yancey's, Yellowstone Park. In 1897 there were at this place long dams and large ponds which Seton mapped and described, and which were inhabited by a flourishing colony of beavers. In 1912 Seton revisited the place and found the colony abandoned and the meadow pretty well formed. The beavers, according to M. P. Skinner, formerly park naturalist, began to desert the place about 1903 or 1904. In 1921 I examined the ground and found most of it solid, and the dams, except the two upper longest ones, so nearly obliterated that it was difficult to locate their sites. Thus in perhaps twelve or fifteen years these meadows assumed their present form.

There is a wide valley here, bounded by hills, and traversed by Lost and Elk Creeks, which is one large beaver meadow. The old Yancey place is situated at the forks of these streams, and Yancey used to cut hay near his place twenty-five or thirty years ago. Since 1920 the National Park Service has been cutting hay here for its own use. Some of the ground is still too soft for the use of a mowing machine. I have information that in 1907 there was a beaver colony on Lost Creek toward the northeasterly part of this area. This is now like the rest of the meadow. Thus it would appear that this meadow is not all of the same age, but was formed at different times, the portion at the junction of the streams being the oldest (Fig. 46).

Another instance in Yellowstone Park is the case of the lowest pond in what I called the "Bench Colony." When I first examined this July 23, 1921, it was full of water (Fig. 48). This gradually receded during the summer, and when I saw the pond for the last time that year, September 4, it was more mud flat than pond (Fig. 49). Figure 50,

FIG. 45. A HOLE ON SHORE REACHED BY AN UNDERGROUND PASSAGE FROM
THE STREAM

FIG. 46. THE BEAVER MEADOW ON LOST CREEK

UPPER: FIG. 47. A BEAVER TRAIL THROUGH WILLOWS
LOWER: FIG. 48. POND IN THE "BENCH COLONY," FULL OF WATER,
JULY 23, 1921

UPPER: FIG. 49. POND IN THE "BENCH COLONY," PARTLY DRAINED,
SEPTEMBER 4, 1921

LOWER: FIG. 50. POND IN THE "BENCH COLONY," WELL ADVANCED
TOWARD A MEADOW, AUGUST 17, 1923

UPPER: FIG. 51. A POND IN COLORADO, PHOTOGRAPHED OCTOBER 8, 1913

LOWER: FIG. 52. THE SAME PLACE, OCTOBER 18, 1922. ALL TRACES OF
A POND HAVE DISAPPEARED. THE CHANGE REALLY TOOK
PLACE IN TWO YEARS

FIG. 53. A BEAVER MEADOW COVERED WITH A DENSE GROWTH OF WILLOWS

taken August 17, 1923, shows the pond practically all covered with coarse grass. There were still soft muddy places here and there, and the channel which can be seen was very soft mud, as my assistant discovered when he stepped on it and went in above his knees.

In a case which came under my observation in Colorado I found on a small stream a good-sized pond containing a lodge. This pond was formed by a dam one hundred and thirty feet long. This was in 1913. The following year the dam was broken through at the stream channel, and the pond drained, and in 1915 it was overgrown with grass. When examining the place in the autumn of 1922 I found that the stream channel had been very much deepened, presumably by a flood the previous year, and a new dam built between the banks, forming a pond over two hundred feet long. The old dam, though almost obliterated in places, could be traced on either bank above, more than four feet higher than the new water level. The old pond was now a meadow covered with grass and the old lodge a ruin (Figs. 51 and 52).

The character of the material with which a beaver pond may be filled is variable. Sometimes it is a fine silt which makes an excellent soil, and probably this is the first material to be deposited. On the other hand I saw some ponds in the Yellowstone which were being filled, or were already filled, with a coarse gravel. At Longs Peak Inn, Colorado, the site of an old beaver pond was excavated to make an artificial pond, and here I found a fine gravel or coarse sand resulting from the grinding up or disintegrating of the granite country rock. This seemed to be devoid of humus or vegetable matter which might serve as plant food. On top of this, however, there appeared to be a layer of black mould in which grass and willows grew.

Many beaver meadows become covered with a dense growth of willows, almost impenetrable at times (Fig. 53).

CHAPTER VIII

FOOD AND TREE CUTTING

The beaver's food is exclusively of a vegetable nature, and no matter how the ponds and streams in which the beaver lives may abound with fish it never harms them. The preferred food would appear to be the bark of trees, and it is the inner or cambium layer, the one between the outer bark and the wood, which is mostly eaten, not the tough outer bark. In the case of small twigs, however, or stems like those of small willows, it would seem likely that all the bark is eaten, the outside layer being too thin to be conveniently discarded. While deciduous trees are almost universally used, conifers are also sometimes utilized. The thick bark of large trees is unfit for food, though I have seen large aspen logs from which the bark had been eaten and none of the outer bark discarded.

The following trees are mentioned by different authors as being used for food by beavers: Aspen or poplar, cottonwood, willow, alder, box elder, different species of birch, yellow birch being preferred (Morgan), wild cherry, pin cherry, viburnum or witch hopple, black and white ash, soft and bird's-eye maple.

These food trees vary with the locality, but almost everywhere the aspen seems to be preferred above all others, and in the Rocky Mountain region it is *the* food tree of the animal, for, aside from cottonwoods, willows and alders, the other species are mostly noticeable by their absence.

In the summer beavers would appear to be less dependent on bark for food, and eat many other things, perhaps for a change in diet, and perhaps as a conservation measure to

avoid drawing too heavily on a food supply which must be used in winter.

The following plants have been mentioned or have been noted as being used in summer: Raspberry bushes, various sorts of roots and grasses (Morgan); roots of water lily and spatterdock (Dugmore); berries, mushrooms, sedge (Mills); wild rose bushes, cow parsnip, thistles (Warren); hazel, cornel, service berry (Bailey).

I also noticed that other plants such as wild geranium had been cut where a beaver was feeding, but have no evidence that they were eaten, though presumably they were. In the case of the bushes, as well as the seedling aspens which are often cut at this season, leaves, wood, and bark all appear to be eaten.

Howell, in the Biological Survey of Alabama, says that in one locality in that state, wherever cornfields bordered the lake deeply worn trails were found leading into the fields, and it was stated that in summer beavers resorted regularly to the corn patches and consumed a considerable quantity of corn. A planter told of finding one standing up in a cornfield and reaching for an ear of corn. This is the only mention I have seen of beavers destroying farm crops.

Much has been said and written about the tree-cutting activities of the beaver. First I wish to say that it is extremely rare, if ever, that a beaver cuts a tree with the idea of having it fall in a certain definite direction. Enos Mills told me that he had seen one or two instances where such *might* have been the case, but he did not know if it was so. As a matter of fact, most, if not all, beaver-cut trees fall in the direction towards which they happen to lean. Wind may occasionally influence the direction in which a tree falls.

The powerful incisor teeth are the tools with which a beaver does his tree cutting, and most efficient tools they are.

One or two bites are sufficient to cut a bush a half-inch or so through. In cutting trees of any size chips are taken out by first cutting at either end and then prying out sideways with the teeth. In trees of such a size that a wide scarf has to be cut good-sized chips are often removed, especially from soft woods, such as aspen. I have seen chips of the latter wood seven inches or more long. On an aspen seventeen inches in diameter, which was cut evenly all around, the width of the notch in the wood was $9\frac{1}{2}$ inches. In a lodge-pole pine twenty-one inches in diameter, on which all the cutting was done from one side, the notch had been made seventeen inches high. Pine wood being harder than aspen the chips are smaller, four inches being the longest I have found, and this pine must represent relatively much more work than the aspen mentioned (Figs. 54 and 55).

Judging from my own observations and from what others have written, the great majority of trees are cut through from one side, especially in the case of the smaller ones, and the side from which the cutting is done is selected more for its convenience than for any other reason. On a hillside nearly all the trees will be cut either from the up-hill side, or from one side or the other, and only a few from the lower side. Now a man in cutting a tree makes his deepest cut on the side toward which he wishes the tree to fall, but the trees which a beaver cuts on a hillside will nearly all fall down hill, no matter from what side the cutting is done. This is because most of the trees naturally lean down-hill, and therefore fall that way. Similarly trees growing along a stream tend to lean toward the water, and when cut, fall in that direction. It should perhaps be mentioned that Dugmore says that most trees are cut all around the trunk, and that may have been the case where he made his studies, in Canada and Newfoundland. It is the larger trees standing on level ground which are most likely to be cut evenly

UPPER: FIG. 54. CHIPS CUT FROM ASPEN
LOWER: FIG. 55. CHIPS CUT FROM LODGEPOLE PINE

LEFT: FIG. 56. TOOTHMARKS OF BEAVER ON ASPEN TREE

RIGHT: FIG. 57. A COTTONWOOD TREE CUT BY BEAVER

all around. This of course makes the work somewhat easier, for then not as wide a notch has to be cut as when the cutting is all done from one side. Figures illustrating this point have already been given, in the cases of the large aspen and pine.

On a steep bank by Tower Creek I found two aspen stumps close together, about three feet high. Each had a notch cut on the lower side, but the cuts which felled the trees were made on the up-hill side several inches above. Evidently the beavers had decided it was unsafe to continue cutting below, and had gone to the upper side to finish the job (Fig. 60).

A beaver does not always work continuously to cut down a tree. Thus the seventeen inch aspen was first seen July 20, when it had a notch cut around it, not especially recent work though, evidently done some time the previous spring or early summer. The tree was seen quite frequently during the succeeding weeks, and was still standing August 28. On September 4 it was found to have been felled during the week preceding. In the Colorado Museum of Natural History, Denver, is a cottonwood stump $29\frac{1}{2}$ inches in diameter, concerning which Director J. D. Figgins wrote me that there was evidence of long intervals between cuttings.

Shiras states that a colony, estimated to contain eight beavers, had from twenty-five to thirty trees in the process of felling at one time, showing that they did not always work at a tree until it was felled. "On an average it took from ten to fifteen days before large trees were felled by reason of this intermittent cutting." He also shows a picture of a beaver cutting on a black ash ninety-one inches in circumference. Beavers worked at this tree in three different years and never cut it down.

There is much variation in the height of beaver-cut stumps. I have found a few two or three inches high, or

even less, invariably of very small trees, an inch or two through. I found a group of half a dozen aspen stumps, three to four feet high; the trunks were lying there unused. Possibly they were cut when the snow was deep, and the woodcutters were caught by some enemy, cougar, wolf or coyote. Sometimes a stump, which at first glance appears unusually high, is seen on a little closer examination really not to be out of the ordinary, due to the circumstances under which it was cut. In the Longs Peak region, Colorado, I found an aspen stump forty-nine inches high. It stood beside a large rock, and it was very plain that the beaver stood on the rock when it cut it. The trunk was still attached to the stump, and green leaves were on the tree, though its tip was resting on the ground. Many a tree is cut by a beaver working from a fallen log, and stumps cut on a hillside where the work is mostly done from above will average higher than those cut on level ground.

By the Lewis River, thirteen miles below the Thumb, I came across a group of most unusually high stumps, all lodge-pole pines. They varied from $4\frac{1}{2}$ up to 8 feet 8 inches in height. I think the last must be a record. I have seen no reference elsewhere to one as high. The tree was six inches in diameter. The other trees ranged in size up to nearly twenty inches through. Evidently they had been cut when the snow was deep, three feet and upward, presumably in the spring. Other trees around had patches of bark gnawed off at about the same heights. Still others had been attacked close to the ground. One tree had a spiral notch, beginning 51 inches above the ground, and going more than completely round the trunk (Figs. 62 to 66).

By far the greater number of trees felled by beavers are small; possibly eight inches in diameter would cover the majority, but that does not prevent them from attacking much larger trees at times. The large cottonwood, and ash

UPPER: FIG. 58. ASPENS CUT BY BEAVER

LOWER: FIG. 59. COTTONWOODS CUT BY BEAVER

UPPER: FIG. 60. ASPEN STUMPS CUT TWICE

LOWER: FIG. 61. TANGLED TREES

FIG. 62. THE RECORD STUMP

FIG. 63. A STUMP SIX FEET HIGH

FIG. 64. PINE WITH BARK REMOVED BY BEAVER

FIG. 66. PINE WITH A SPIRAL NOTCH

trees mentioned above are examples of this. Mills records a stump 3 feet 6 inches in diameter, on Jefferson River, Montana, near the mouth of Pipestone Creek. In the "Nature Room" at Longs Peak Inn is a cottonwood stump having diameters of 32 and 28 inches at right angles to one another. Vernon Bailey, in the Mammals of the Glacier National Park, figures a cottonwood stump 46 inches across. Judging from the picture this was quite irregular in shape. This is the largest of which I have any knowledge.

Considering the tools with which it works a beaver can fell trees quite quickly. Mills states that a four-inch aspen can be cut in about an hour. Dugmore says that a single beaver will cut down a tree eight to ten inches through in one night. Morgan makes the statement that with three beavers working on a tree at once, two nights at most would be ample to bring down a tree a foot in diameter. Bailey says that an old beaver will fell a three or four inch aspen, cut it into sections four to eight feet long, and drag it to the water in one night.

There is a difference of opinion among observers as to how many beavers work upon a tree at the same time. I think most doubt if more than two ever do, and that number infrequently. Another point on which opinions vary is as to whether, when a tree is about to fall, the beaver doing the cutting gives a signal by striking the ground with its tail as a warning to other beavers nearby. I suspect that the signal is sometimes given and sometimes not, just as a beaver often dives without slapping the water with its tail, even when alarmed. I have seen a beaver which I came upon unexpectedly as it was swimming in a pond, slip quietly below the surface without a sound.

In cutting trees the beaver usually stands on its hind feet with the wide, heavy tail stretched out behind as a balance, but some trees are cut so close to the ground that the animal

must have been on all fours, and others may be cut when the beaver is standing up and working as high as it can reach. One or both fore feet are placed on the trunk while the work is being done.

There are many mischances connected with tree felling. The top of a tree may lodge in the branches of an adjoining tree so that it does not fall to the ground (Fig. 61). Once in a while it may be released by cutting the obstructing tree, but not often. Sometimes part of the trunk can be cut off. I found an aspen four inches through whose top had lodged in another tree a short distance away. Evidently it had been leaning considerably, and the beavers had cut off so much that the end of the suspended part was only about half the size of the stump and was nine feet away from it, and over two feet from the ground. Attempts to release an entangled tree are usually made by cutting the trunk a second, and even a third time, presumably with the hope that as the tree settles after the new cutting it will clear itself of entanglements and fall to the ground. This it does at times, and, I suspect, just as often does not. I found in the Longs Peak region twin aspen stumps, two feet high and two inches in diameter. Another aspen had been felled and caught between them, and all of it cut off and carried away except a piece eight inches long and $1\frac{1}{2}$ inches in diameter which still remained between the two stumps. Of course there was nothing to show which tree had been felled first, but presumably the entangled one, for it could hardly have caught between the stumps if the other trees had been cut first.

The next step after the felling of a tree is the trimming of the branches, and then the cutting of the trunk into lengths suitable for transportation to the food pile. The length of the pieces into which a log will be cut naturally varies with its diameter. Morgan states that logs five inches

FIG. 66. PINE MUCH CUT INTO

UPPER: FIG. 67. A PIECE OF ASPEN CAUGHT BETWEEN TWO STUMPS

LOWER: FIG. 68. WILLOW BRUSH STORED IN A POND

in diameter are cut into one-foot lengths, four inch logs into eighteen-inch and three inch into two-foot lengths. This hardly seems correct to me, for I have seen good-sized logs cut from eight to twelve feet long. I consider it most likely that the ease with which a log can be carried to the water has much to do with the matter. Where brush, fallen logs, or other obstructions interfere with getting the harvest to the water the animals may clear the way somewhat by cutting out bushes or roots. These trails often pass under fallen logs, as mentioned elsewhere. Much of the smaller brush, or its bark, is eaten when cut.

Most of the tree cutting is done in the late summer and in autumn in preparation for winter, and the wood so cut is stored in the pond for the winter's food, usually close to the lodge or conveniently accessible to it. The fact that this material is stored under water has given rise to some absurd fables to account for its remaining beneath the surface. Thus it was said, and I have seen it repeated quite recently in a sportman's magazine, that the beaver sucks the air out of the wood in order to cause it to sink! Certainly a remarkable performance when one considers the size of a beaver's mouth and the size of some of the logs. The real explanation is that the green wood is so heavy that it soon becomes waterlogged and sinks. The lowest layer probably is forced into the bottom and the other stuff piled on it, very likely in such a manner as to entangle it with that below, and soon absorbs enough water to keep it down.

Mills says that the first portions of the foodpile consist of entire trees, limbs and all, which are usually placed in a rude circle with the butts inward and the tops outward, and this forms an entangling foundation which holds in place the succeeding material. Morgan states that freshly cut yellow birch will barely float.

The size of some of these foodpiles is sometimes quite

extraordinary. Mills gives the size of one in the Moraine colony as three feet deep and 124 feet in circumference. To make this 732 aspen saplings were gathered, also several hundred willows. Another harvest pile mentioned by him was four feet high and ninety feet in circumference. One foodpile which I saw in Gunnison County, Colorado, consisted entirely of willows, the large ends of which were stuck into or against the bank of the pond. The stuff was from three to seven or eight feet long, placed in water four feet or more deep, from the bottom up to the surface, and extending along the shore of the pond for over a hundred feet. Another brush heap which I saw not far away must have contained over eight hundred cubic feet of willow boughs, which apparently were never used, for when I saw them the pond had been drained, though I am sure no beavers had lived in it for a year or two, and the bark was rotting from the brush. Presumably the beavers were trapped before they could use their store. If the stored food is not used during the winter it is abandoned, never used at all, the animals evidently preferring fresh provender in the spring (Figs. 68 and 69).

In moving logs to the pond or canal the beaver adopts such methods as are best suited to the circumstances. It may push or roll them over the ground until the water is reached, or if their size permits, take hold with the teeth and drag them alongside itself, or drag them along while walking on its hind legs, supporting the stick with the hands. Sometimes the stick is thrown over the shoulder while held by the teeth. I have seen marks on the ground as if a stick three or four inches thick had been dragged down a hill from one pond to another. I think branches and brush are always carried by being dragged alongside, certainly the marks which I have seen in trails would indicate that such is the case. At Camp Roosevelt we used to walk down the Cooke City road in the evening to watch the beavers at a colony

there. The animals did not mind spectators and came out of the water and went up the opposite hillside to gather food. Wild rose bushes, which grew in profusion, seemed to be especial favorites, and a beaver would be seen cutting these, seemingly taking hold of the end of each, as fast as cut, with its mouth, until it had accumulated as many as it could hold. Then it would waddle down the hill dragging the mass of green beside it, this often looking as large as the beaver itself. Little aspens, a foot or two high, were cut and carried in the same manner.

Once in the water the food is transported by holding with the teeth and letting it float beside the animal as it swims to the foodpile, on reaching which it dives down and forces its load into the stuff already there. Then it will remain until it absorbs enough water to stay down even though it may become disentangled. Such food as the rose bushes or small aspens was either eaten on shore, occasionally in shallow water, or taken into the lodge.

The logs are not always taken away as soon as cut, though the branches and limbs may be disposed of very soon. The beaver does not always see the need of hurry, or of working all the time, and logs may be seen lying on the ground for some time after felling, and then removed gradually as needed, or at least in time for storage. Mills mentions two colonies in the Longs Peak region not far apart which had somewhat different methods of working. In one colony it was the custom to move the felled trees promptly to the storage pile, while in the other most of the harvest was cut down before the moving began. I have seen both of these colonies and could see nothing about their respective situations which might account for this. Possibly one or both have changed their methods in the years which have elapsed since Mills made his observations, perhaps adopting modern ideas of efficiency.

When unusually large trees are felled only the branches and upper portions of the trunks are used. The bark on the remainder is eaten from the log as it lies on the ground, or sometimes left and allowed to go to waste. The casual observer seeing this may perhaps blame the beaver for wanton destruction of the timber, when really the animal has used all that was of any service to itself. What more can we ask? Does man do any better, or as well? I must admit, however, that in the case of several large pines which I have found, cut by beavers and never used, I am at a loss for any explanation of such work. Some of these trees were so large that it must have been difficult work and taken much time to bring about their downfall.

Speaking of pines brings me to the use of the bark of conifers as food. All the authorities say this is rare, and appear to think it may result from necessity, due to the scarcity of other food. The more one studies an animal, the more occasion he is apt to find to modify his preconceived ideas, and so it proved with me in this case. In the Longs Peak region in 1922 I found numerous lodgepole pines from which the beavers had removed some of the bark, even when other food was close at hand. The trees were not cut down, but the bark had been taken off in triangular patches or strips, the apex of the triangle above, as if the animal had cut across the lower end, then loosened it and torn the bark upward, causing it to come off in this form. Occasionally oblong patches were found and once or twice a girdled tree. The trees from which the bark had been removed were from five to ten inches through. I found few or no chips at the bases of the trees, and never any of the bark. Some saplings were found which had practically all the bark eaten from them. Sometimes I found the tips of pine boughs in the water close to the shores of ponds, showing beaver toothmarks on their ends. While I have no proof

FIG. 69. WILLOW BRUSH STORED AT LODGE

FIG. 70. PINE WITH BARK REMOVED BY BEAVER

that this bark was eaten, I have but little doubt that it was, for I know of no other use to which it would be put. The beavers would hardly be likely to use it for bedding, no matter how fond they might be of the piney odor, for the pitch would soon soil their fine fur coats (Fig. 70).

In 1923, in the Yellowstone Park, I gathered much more evidence as to the use of conifer bark by beavers. Visiting the Crescent Hill colony for the first time in two years, and with much curiosity as to what developments had taken place during that time, I found that the inhabitants were obtaining part of their food from Douglas firs. On very large trees they were cutting away the thick outer bark, which lay strewn about on the ground, and were eating the inner bark to a height of two feet from the ground. One tree was almost girdled in this way, and the beavers had also scraped the earth away from the roots and eaten the bark from them. Smaller trees had been cut down, tops and branches cut off and carried away, and the logs remained practically denuded of their bark. At one place beside the Yellowstone River several firs were found which had been attacked in the same way. At another place by the Yellowstone I found where Engelmann spruces had been cut several years ago (Fig. 71).

At the above mentioned locality on the Lewis River several lodgepole pines had had the bark removed in much the same manner as in the Longs Peak region.

At various other colonies near Camp Roosevelt I found where beavers had used small firs and spruces.

I have therefore come to the conclusion that the beaver makes much more use of conifer bark than it has been supposed to do.

Dugmore says that he has been told by trappers and Indians that about the time the young are to be born the pregnant female eats a small quantity of conifer bark,

which is supposed to have some medicinal quality. I can not help wondering how the trappers happened to discover this interesting fact.

J. S. Newberry, speaking of the beaver in the Cascade Mountains, one hundred and fifty miles south of the Columbia River, said they cut off whole groves of young pine trees and carried them away bodily.

It is almost invariably stated that the bark is the food which is obtained from the trees cut by the beaver, and doubtless this is true to a great extent, if not entirely so. Morgan, however, was of the opinion that wood itself formed a considerable portion of the beaver's food. He mentions instances where trees had been cut into apparently for the express purpose of eating the wood, as no chips remained about the trees, which were not entirely cut down. He also refers to the sticks and logs so often seen about beaver work which have apparently unnecessary notches cut into them, and thinks this was done to get the wood. I have often wondered myself why this was done, and the thought had entered my mind that the wood had been eaten, and yet it seemed so unlikely when there was plenty of bark that I hardly gave the idea serious consideration. Sticks three to five inches in diameter are often found having cuts in several places close together, going all around the stick but not quite severing it. If the wood was not eaten the only other likely use of it would be for bedding. Otherwise the beavers were just whittling (Fig. 72).

Morgan gives somewhat more convincing evidence with regard to this in the stomach contents of three beavers taken in February and March and sent out for dissection. Doctor Ely, who made the dissections, "found their stomachs filled with lignine, with a slight intermixture of the tendrils of forest trees, and no perceptible remains of bark. The comminuted particles were so clearly of wood as to leave no doubt upon the question."

FIG. 71. DOUGLAS FIR WITH BARK REMOVED FROM TRUNK AND ROOTS

UPPER: FIG. 72. PIECE OF ASPEN MUCH GNAWED BY BEAVER
LOWER: FIG. 73. YOUNG BEAVERS IN THE LODGE

In the Longs Peak region I found in two different ponds on the same stream dead lodgepole pines some of the roots of which had recently been cut off by beavers, and some of them quite close to the trunk. At one of the ponds a piece of a root was floating in the water by the tree. I saw no indications as to what use, if any, had been made of the portions cut off. I also saw a pine in Tower Creek the ends of the roots of which had been cut off in this way.

We have little information as to how far away from the water a beaver will go in order to cut trees. The greatest distance which I have found was at Lily Lake, Estes Park. Here trees had been felled more than four hundred feet from the shore and dragged down the hill to the water. At Crescent Hill, Yellowstone Park, trees had been cut two hundred and twenty feet from the pond, but there were no aspens growing farther away, and never had been. Vernon Bailey says "trees have been cut as far back as ten or twelve rods from the shore, but track, trace, or trail of beaver is *rarely if ever found farther from water.*" Italics mine.

In summer beavers seem to make grass a portion of their food. I have seen grass floating in ponds where there was no indication of muskrats, and have sometimes seen where it had been cut on shore. In the Yellowstone I saw beavers carrying grass in their mouths dive down into the lodge, where it may have been eaten or used for bedding. Observers in other places mention seeing where grass had been cut along shore. It is evident the animals use a goodly variety of food during the summer, perhaps as a relief from the enforced monotony of the winter diet of bark.

In connection with beavers eating grass Taylor speaks of what he calls "grass beaver." These lived where there was little or no brush and fed on grass, and were never as large and sleek looking as those living on bark.

CHAPTER IX

BREEDING AND FAMILY LIFE

The family life of the beaver would appear to be quite a model one. With an exception to be noted below all observers and writers seem to be agreed that the beaver is monogamous and mates for life. The young remain in the lodge or burrow until they are fully grown, when they leave the old home, but often set up a new one for themselves in the same pond. This might be likened to a human family where the old folks remain in the homestead while the children build new homes nearby, and all unite in working together for the common good.

When we come to look into the matter not as much appears to be known of some of the breeding habits of the beaver as we might have a right to expect after all the years we have known the animal. The creature's habits are in themselves obstacles to gaining information as to some things. Thus the rutting season does not seem to be definitely known. MacFarlane thought it was in January and February, but in those months over much of its range the beaver is living in ice-covered waters and not to be seen, much less studied. The same writer thought the period of gestation was about three months and the young were born in April and May. This last fact seems pretty well established. He states that the young are born blind and helpless, while Dugmore says the eyes are open at birth, basing his statement on what he had been told by trappers and others.

The number in a family seems to be quite variable. Perhaps the usual number is about four. As few as one has

been noted in a litter, while MacFarlane says seven and eight were not uncommon on Peace River, and an Indian told him of finding nine embryos in a female killed on lower Peace River. It should be mentioned that Hearne, who spent several years in the northwest fur country, found as many as six foetuses in a female in but two instances. Morgan mentions a trapper who found eight in a female caught by him, and who also found eight in a lodge. Earl Theron Engle says that two beavers taken in South Boulder Cañon, Colorado, February 23, 1924, each contained three embryos, 7 mm. and 9 mm. in length. The government trapper who procured the animals said that the record is the earliest observed in several years trapping.

One spring Mills visited several colonies to see if he could find out the number of children in a family. He saw one family of eight, and one mother had but a single baby. The average number was five. On May twelfth he saw six youngsters sunning themselves on top of a house. The fact that a beaver has but four teats might seem to indicate that four was the normal number of young.

I have previously stated that there was an exception to the almost universal belief that beavers take but a single mate. Vernon Bailey makes the following statement: "Like all rodents, beavers are polygamous, and the fact that fights among the males take place indicates that the older ones strive for supremacy." He also says that in August he found two females, one male, and six good-sized young in one house. As the sexes seem to be about equal in number polygamy appears rather doubtful to me.

The male apparently leaves the home lodge or burrow about the time the young are to be born and takes up his abode in a burrow elsewhere. When the family are a few weeks old he returns to the lodge. Morgan states that at the age of six weeks the young will wean themselves

and take to eating bark, while Bailey says that young beavers may be weaned at two months of age. Dugmore says that they come out of the house less than three weeks after birth.

Joseph Dixon, Museum of Vertebrate Zoölogy, University of California, has very kindly given me some notes concerning the breeding of beavers in California. In that state the majority of young are born in April, chiefly in the first half of the month, though a few litters make their appearance during the latter part of March. Mr. Dixon also has record of small young, not more than a few days old, having been found as late as the first of May. He found, April 15, 1921, that the young were fourteen inches long and not more than a week old. They made no attempt to escape when the house was dug into, and were picked up and handled as though they had been kittens. The following season a number of houses were visited which contained young two or three weeks old, and these could not be captured, as they dove into the water through the entrances when an attempt was made to dig cautiously into the side of the house. In this case the youngsters were admittedly frightened from the house. However, even when, so far as was known, there had been no disturbance to cause the baby beavers to leave the house, it was found by muddy tracks at the margin of the pond that young beavers left the lodge when from three to four weeks old. In another instance a mother beaver and her three young, all about the size of large cottontails, were seen to ramble about in the rank grass some twenty feet back from the margin of the pond. This was late in June, probably six weeks after the other baby beavers had been born. This may have been a second litter. Mr. Dixon concludes his letter by saying: "Personally, I have every reason to believe that in California youngsters begin to venture out, normally, when they are about three to four weeks old."

In this connection I wish to record the observations I made in Yellowstone Park. A lodge was under observation continuously from the early part of July, and though we saw two adults and three yearlings on nearly every visit, we saw, though watching for them, no young of the year until August 22, when three made their appearance, the size of large muskrats. I estimated the length of one which I was able to observe very closely for some time at eighteen inches. If Dixon is correct in giving the age of young fourteen inches long as a week these could not have been more than two weeks old. After that day they were often seen. It seems strange that they should have attained such a size before showing themselves, especially when the others of the family showed no particular fear of the spectators who stood on the shore of the pond practically every evening. This was in 1921.

In 1923, at another pond in the same region, we spent several evenings watching the beavers, which were quite indifferent to our presence on a dam at the upper side of the pond. They swam about close to us, also going away to the farther end of the pond and there gathering young aspens, rose bushes and willows. The lodge was but a short distance from where we were, and another lodge was also built in the dam above mentioned, which seemed to be honey-combed with tunnels and passages. Young could be heard in both lodges, into which food was taken, but the youngsters never appeared outside, though we had observations as late as August 25. We saw both adult and yearling beavers on every visit.

My Yellowstone notes seem to be much at variance with the above observations of others, unless, indeed, the young observed there were second litters. The later season in the Yellowstone might possibly make some difference in the breeding as compared with California, but hardly enough to

account for such great discrepancies. The subject is a puzzle to me with the data at hand at present. Vernon Bailey says there seems to be no evidence of more than one litter in a season.

In the Yellowstone I noted something which I never have seen mentioned anywhere. It was the feeding of the yearlings by the adults. One of the latter would be seen to go on shore and return with a load of green food, with which it would swim to a certain part of the pond. Here a yearling or two would join it and take part or all of the food and eat it. If only a portion was taken the old one carried the remainder into the lodge. This was seen several times on different evenings. No yearlings were seen to go ashore where the adults did, though a few times one did go out at other places for a little willow brush. I can not help wondering if these "yearlings" may not really have been the first litter of the year, which probably would grow to a good size in three months.

Foster parentage is not unknown among beavers. Mills gives specific instances, and Dugmore also speaks of the matter, possibly following Mills.

On the whole the home life of the beaver appears to be a not unhappy one—when man leaves him alone. The beaver works when necessary to obtain food, or to build dams, canals or houses. But that does not occupy all its time. No building operations are carried on in spring or early summer, the season of high water, nor is much tree cutting done until late summer. From this time on, over much of the animal's range, it is busy preparing for cold weather, repairing dams and lodges, and gathering food. When winter comes and everything is frozen up, all there is for it to do is to eat and sleep. In the summer some beavers like to wander about. These are the males, and possibly yearling females. Mother beavers must stay at home and

look after the family. These wanderers sometimes stray far from home and even from water, for I have been told of one having been seen on a dry divide in the Yellowstone a long distance from the nearest water. The purpose of this wandering is not quite clear. Perhaps in some cases it is to find a new location, in others just to get away to new scenes for a while. It is not even clear whether the travelers ever return home, though they are supposed to do so. In the case of two-year old beavers they may be looking for mates, or pairs may be prospecting for homesteads. In this connection it may be mentioned that while the female beaver probably does not usually begin to breed before the age of two years, Bailey says that instances are known of single foetuses being found in year-old females.

Like all animals, wild or domesticated, young beavers are playful. Their play, so far as I have myself observed, and I think also others, is in the water, and seems to consist mostly of pushing and pulling one another about. Yearlings which I saw playing appeared to get their heads against one another's shoulders and push until one went over. I have seen a youngster thus rolled completely over in the water. Probably there is but little play on land. They are too awkward in their movements there for this to be safe.

Beavers are said to live from twelve to fifteen years. Mills had glimpses of a beaver he called "Flat-top" during a period of eighteen years, and thinks it was at least four years old when first seen, making its age at least twenty-two years.

The trappers told Father DeSmet that those beavers which were lazy and unwilling to work were exiled from the colony, and forced to live apart at a distance in a state of starvation in the winter because they had not put up food. They were easily caught, but their fur was not as good as that of other beavers because of lack of food. This tale has been current with variations for many years.

CHAPTER X

SWIMMING AND WALKING

SWIMMING

It is of course in the water that the beaver is most at home, and naturally with the structure and aquatic habits of the animal, it is a far better swimmer than walker. It swims easily at or beneath the surface, usually at a rather slow or moderate speed, using its hind feet for propulsion, for which their size and webbed structure are admirably adapted. Bailey says that when alarmed beavers can swim under water as fast as an otter or a seal, while Seton thinks they rarely swim faster than two miles an hour. Bailey says that the tail is effectively used as a propeller when speed is desired.

Dugmore says that in swimming the hind feet are used, and to a very limited extent the tail, chiefly for sudden starts or turns. In this it differs from the muskrat, which swims chiefly with its tail, which it uses as a scull. In comparing beavers and muskrats Shiras says "Unlike the muskrat, with its body well out of water, the beaver swims nearly submerged, with only the head showing. At a distance it is sometimes hard to tell one from the other when swimming, except by the greater speed and wake of the beaver."

Dugmore says that upon the speed at which the animal is going depends the amount of the back which is visible. He says that he has never been able to make absolutely sure that the tail is employed as a propeller, except for a few strokes on a sudden burst of speed.

Johnson says the propelling organs are the hind feet. He has never seen the tail used as a scull, and believes that it is principally used as a rudder. When the animal is swimming straight away the hind feet strike out together, and when it is turning the strokes may alternate.

Beavers which I watched closely when they were swimming by daylight in Yellowstone Park of course used their hind feet for propelling, but not exclusively. Though the tail was usually carried motionless behind, I sometimes saw it used with a sculling motion. As at such times the animal went straight ahead the tail was not then being used for steering, though I did see it used for that purpose on other occasions. Sometimes the swimmers turned without using the tail for a rudder, evidently doing it by means of the hind feet.

The fore feet are not used at all in swimming, being then folded against the body.

A beaver can remain under water for a considerable period. Bailey says commonly four or five minutes at a time, but that they can swim half a mile or more without coming to the surface, and have been timed for 15 minutes under water in traps. When moving about under the ice in winter they may get air from bubbles under the ice or from open holes. Mills says they can swim two hundred yards under water without coming to the surface, and can remain under water five to ten minutes. On one occasion one stayed under water more than eleven minutes. Dugmore says (p. 77) eight to nine minutes, and (on p. 13) six to seven minutes.

The above-mentioned Yellowstone beavers did but little slapping with the tail. They often dived without apparent reason, usually quietly, but sometimes noisily. Even small sticks thrown into the water near the animals did not trouble them. Something which did cause one to slap its tail was a

camera which I had set on a tripod on the dam near the trail where the animals crossed, hoping to obtain a picture. One came near this, evidently intending to land, but on seeing the camera dived with a great splash, and it and another afterward swam about, occasionally diving with slaps as if to manifest their displeasure.

Dugmore says that his photographs show that when a beaver slaps the water with its tail in diving the head and shoulders are held high out of the water as the tail is raised. This slapping with the tail is a well known habit of the beaver, and one which is made a good deal of by some writers. The slapping appears to be a danger signal, but even when alarmed the beaver does not always give it. I once came suddenly upon a beaver as it was swimming in a pond in midday, and though it must have been frightened at my unexpected appearance it dove quietly and without the least noise. One day at the Crescent Hill colony in the Yellowstone Park we were eating our lunch on the opposite side of the pond from the lodge. A beaver kept coming out, swimming around and then disappearing until I could stand it no longer, and picking up my graflex, I crossed on the dam and stationed myself at a favorable point. Presently I was able to make an exposure. The beaver dived at the sound of the shutter without any disturbance. Encouraged by my success I went somewhat nearer the lodge, and presently my subject reappeared. Evidently I was too close this time, for as the shutter went the beaver dived with a tremendous splash which threw water all over me, though I was some twenty feet or more away. At another colony in the Yellowstone I was watching a beaver feeding one afternoon, when it suddenly disappeared, and a few minutes afterward I discovered it quite close to me, floating motionless in the water, with only the head out. Then it returned to its feeding place. This was repeated two or three times,

the animal always moving so quietly under water that it made no surface disturbance.

This floating quietly is something which the beaver seems fond of doing. The animal rests easily with the upper part of the head and back out of water, and the tail on the surface. Sometimes it appears to be done for purposes of observation, at other times the animal seems to be resting, or perhaps loafing.

Sheldon, in "The Wilderness of the Upper Yukon," says he twice saw beavers dive when they were unsuspecting, and in both cases they slapped their tails. Selous mentions two instances of beavers on the bank which were not alarmed by the tail slaps of others, even when close-by. Sheldon thinks some other interpretation of the habit than an alarm must be attempted, that perhaps it is a muscular contraction to assist in sudden diving.

A somewhat similar use of the tail is that of thumping the ground with it when a tree is about to fall, as a supposed signal to the other beavers around to look out. As stated elsewhere there is a difference of opinion about this.

WALKING

Walking is far from being one of the beaver's strong points. On the contrary it is a method of progression for which its build does not adapt it, therefore its walk is decidedly awkward, at times very much like a waddle as it moves about over the ground on its various errands, cutting trees, or gathering bushes for food. Quite different is the ease with which it moves in the water, its real native element.

For a faster gait a beaver uses a clumsy lope or gallop, not very fast, for it is said that a man can easily outrun an adult, and any of its four-footed enemies could do so without trouble. I once had a rather amusing experience with a beaver, though it was in the water instead of on land. The

animal was swimming in the pond almost directly below where I stood on the bank several feet above and I made an exposure with a graflex camera. The noise of the shutter startled the beaver, which ordinarily would have dived. Unfortunately for it, however, the water was very shallow and several fallen trees intervened between the place and deeper water. Over these logs the beaver loped and galloped with a great splashing until it reached a place where it could get beneath the surface. The negative obtained showed with what quickness a beaver can get into motion, for the shutter had been set for a very short exposure in order to allow for the movement in swimming, but the negative shows a rather unrecognizable blur, and the position of the animal shows that it began to jump the very instant the shutter was released, certainly quick response to an alarm.

UPPER: FIG. 74. A BEAVER SWIMMING
LOWER: FIG. 75. A BEAVER FLOATING

UPPER: FIG. 76. A BEAVER RESTING

LOWER: FIG. 77. THE BEAVER WHICH COMBED ITS HAIR AFTER BEING
TAKEN FROM THE TRAP AND TETHERED

CHAPTER XI

VOICE; SIGN HEAPS; ENEMIES; DISEASE; PARASITES; BEAVERS AND FISH; BEAVERS AND BIRD LIFE

VOICE

Different writers vary much in their descriptions of the beaver's voice. Morgan says that the cry of a young beaver very closely resembles that of a child a few days old. Mills says that sometimes a strange, shrill whistle is given. Sometimes, when alarmed a young beaver gives a shrill and frightened cry not unlike that of a lost human child. He has heard near a beaver house in early summer a subdued concert going on inside, a purring, rhythmic melody. He says that the beaver also has a love ditty, a rhythmic murmur and sigh, very appealing, and it seems strangely elemental as it floats across the beaver pond in the twilight.

Dugmore likens the voice of the young to the muffled whining of very young babies. My assistant in 1921 said that the noise made by the yearling beavers when playing was like that of a young kitten, only sharper. Seton says that young beavers wail like a crying child; older ones hiss in menace or utter a querulous "churr."

In 1923, some companions who were watching the beavers with me in the Yellowstone Park, where we could hear the young in the lodge, were well agreed that the voice of the young in the lodge was most like the whimpering of young puppies, without any whining or squealing note. One gentleman compared it to the grunting of young pigs, ten to fourteen days old. None of these people could detect any resemblance to the cry of a human child.

SIGN HEAPS

A means of communication used by the beaver, perhaps more especially if it is traveling about the country and wishes to leave some indication of its presence, is what we may call for want of a better name, the "sign heap." Seton calls these things mud pies.

Sign heaps are little cakes or piles of mud near a stream or pond on which the castoreum is deposited. One which it was my good fortune to find on Lost Creek, Yellowstone Park, was placed in shallow water close to the shore, and was a little more than a foot in diameter and three inches thick. It had been made either the preceding night, or the night before that, as we had been there two days previously. It was merely a round cake of mud, but so placed that it stood apart from its surroundings and was really quite conspicuous and easily seen. I could detect no odor about it.

Morgan gives an account of something similar: "After selecting a suitable place upon dry ground near the pond or stream, they void their castoreum here and there upon the grass, and, in the musky atmosphere thus created, spend some hours at play or basking in the sun. The trappers call these playgrounds 'musk bogs.'"

Nuttall, in speaking of trapping beavers, says: "Scarcely anything is now employed for bait but the musk or castoreum of the animal itself. As they live in community, they are jealous and hostile to strangers of their own species and following the scent of the bait, are deceived into the trap" (Fig. 78).

ENEMIES

The arch-enemy of the beaver, as of all other wild life, is of course man. The list of other enemies is short. Cougars, bobcats, lynxes, wolves, coyotes, bears, wolverenes,

FIG. 78. SIGN HEAP OR MUD PIE MADE BY BEAVER

otters, and possibly foxes and fishers, seem to be the four-footed enemies with which a beaver has to reckon. Some of the larger hawks, such as the goshawk, as well as the eagles and great horned owl, may occasionally pick up a small youngster. Dugmore, in his story of the life of a beaver family, tells of a goshawk capturing a beaver kit as it was playing on the shore. As Dugmore was very careful in what he wrote I take it for granted he based his story on facts known to him. He seems to be the only author who mentions birds killing beaver, but I see nothing improbable about such an occurrence as he relates.

Of the other enemies mentioned, all, excepting the otter, probably kill beavers by surprising them when on land, or perhaps occasionally when in very shallow water. They may steal upon a victim when it is at work cutting down a tree, or trimming one after it has been felled, or traveling across country from one water to another. Mills gives several instances where a number of beavers were thus killed by cougars and coyotes. I found in the Longs Peak region in late August, what was left of a beaver which had been killed a few days before by a coyote or coyotes, droppings of which were found close-by. All that could be found of the beaver were a few scraps of fur and of the scaly part of the tail, and part of the intestines. These were but a few feet from the lodge, which was a bank lodge, and presumably at or near the place where the victim had been surprised and killed.

Mills also mentions an instance of a bear tearing open a beaver house, a proceeding which to me looks like a waste of time. While Bruin was trying to break through the thick walls the inmates would quietly leave and all he would have for his trouble would be an opportunity to observe the domestic arrangements of his intended prey.

Comparatively little seems to be known as to the rela-

tions between the beaver and the otter. The latter is fully as much at home in the water as the former, and surely would be a most formidable enemy. In "Fins, Feathers and Fur," March, 1922, James Harris, a Minnesota game warden, reported that in February, on the Superior Game Refuge, he saw where an otter had made a hole through a beaver dam and drained the water off. He said: "Trappers claim that otters do this so as to make an air space to swim around in under the ice and look for food; they will also attack beaver if they find one alone. A local trapper informed me that he had seen a beaver dam in the game refuge where an otter had drained it and had a fight with the beaver, they had driven him out and wounded him as there were blood stains on the trail where he came out." Audubon says that the otter is the worst enemy the beaver has.

Mills, in "Watched by Wild Animals," chapter V, "The Otter Plays on," tells of a battle between an otter and beavers in the latter's pond. Most of the fighting was under water. Several beavers were in the fray against the single otter, which finally broke away and made its escape, and seemingly was badly bitten.

A beaver is essentially a peace-loving animal, and such as I have seen caught in traps made absolutely no fight. One which was caught by a hind toe only, permitted me to pull it by the tail out from under the bank where it was hiding, attach a long wire to a hind foot, and remove the trap. I then dragged it along to an open space on the shore where I could photograph it (Fig. 77). The animal made not the slightest resistance, and appeared quite resigned to its fate. When once on the shore and securely tethered, it began to comb and dry its hair with its claws. And all the time I had been in fear of a nip from those teeth which easily could have made serious cuts if their owner had been inclined to

use them. Male beavers are said to fight among themselves during the rutting season, and scars are found on the hides, made by the teeth of the combatants.

In contrast to my experience is the account by George G. Goodwin, in *Nature Magazine*, of a fight he had with a trapped beaver. The latter freed itself from the trap just as the man, who was waist deep in the water, caught hold of a hind leg. The beaver turned on its captor, biting at his face, but unsuccessfully. Goodwin had no weapon and defended himself with his fist, but without effect. Finally the beaver gave up the attack on the face, swung around, and bit through the top of the man's thigh, making a wound large enough to put the little finger in. This last attack gave the man an opening to get in a blow which laid out the animal until it could be dragged ashore and finished with a knife. This beaver was said to weigh over sixty pounds. This is the first account I have ever seen of a beaver attacking a man, even when it was trapped.

Mills stated that he knew of two instances of bobcats being killed by beavers, but does not give any particulars. If a beaver did choose to make a fight it might easily kill an animal the size of a bobcat by a lucky bite in the neck severing the jugular vein.

Grinnell, in the "Cheyenne Indians," gives some account of the method used by this tribe many years ago to capture beavers. They used the meat for food and the skins for clothing, and trained dogs to hunt them. These dogs were small enough to enter the hole in the bank or lodge, and still were of fair size. A beaver dam would be broken so as to drain the water from the pond. The entrances to the lodges or burrows would be located, and a dog sent in. He would find the beaver, bark at it and worry it until it was angered and fought back, and followed the dog out. The latter gradually backed away, inducing the beaver to follow

by making short dashes at it, and finally backed clear out of the hole, followed by the beaver, which would promptly be knocked on the head with a club by an Indian waiting there.

D. S. Stanley, in the *American Naturalist* for June, 1868, mentions a half-breed at Fort Sully, South Dakota, who owned a female bull terrier which followed beavers into their lodges and pulled them out, having sometimes a severe fight and being badly bitten. "The Indians offer a big price (a large buffalo horse) for the dog." He also states that the wolverene lies in wait for beavers by their trails and kills them.

In the original Journals of Lewis and Clark it is related that on May 19, 1805, somewhere on the Missouri River, Lewis wounded a beaver which was in the water. His dog went in to fetch it out, when the beaver bit the dog in the hind leg, severing an artery, and it was feared the dog would die.

DISEASE

MacFarlane says that beavers are sometimes found dead of disease in their houses, and on the authority of Deschambault, that in such cases the mouth and nostrils are generally infested by small white worms.

From Seton, page 476: "Like others of our beasts this species has its years of increase and decrease, and also is subject to diseases that are as yet not understood. Tanner says of the beaver of the Upper Red River about 1800 [quoted by Coues in Henry's Journal, p. 256]: 'Some kind of distemper was prevailing among the animals which destroyed them in vast numbers. I found them dead and dying, in the water, on the ice, and on the land; sometimes I found one that, having cut a tree half down had died at its roots; sometimes one who had drawn a stick of timber half-

way to his lodge was lying dead by his burden. Many of them which I opened were red and bloody about the heart. Those in large rivers and running waters suffered less; almost all of those which lived in ponds and stagnant waters died. Since that year the beaver have never been as plentiful in the country of Red River and Hudson Bay as they used to be.'"

None of the other authors whom I have consulted have anything to say about disease of the beaver.

PARASITES

Beavers are afflicted, like most other mammals, with parasites, but these appear to be unique in that they belong to the order *Coleoptera*, which is that to which all beetles belong, not to the *Mallophaga*, which includes the biting lice of mammals and birds.

Platypsyllus castoris is the name given to the better known of these parasites, and it has been found on both American and European beavers. It has been recorded from Alaska, Colorado, Dakota, Texas, Nebraska and California in America. Riley (*Castorologia*, Appendix C, p. 238) says that *Leptinillus validus* Horn, is an associate parasite of *Platypsyllus* on the beaver, a number of both having been taken from beaver skins brought from Alaska.

Prof. T. D. A. Cockerell writes me that this is all that is known of its habits. *L. testaceus* occurs in nests of bumblebees and field mice. *L. aplodontia* was found in California on *Aplodontia*, or mountain beaver, a mammal whose habits are very different from the real beaver.

Vernon Bailey says that two specimens of *L. validus* were the only parasites found on four old beavers taken for specimens in Wisconsin. None was found on six young beavers kept in captivity.

BEAVER AND FISH

There seems to be much difference of opinion as to the influence of beaver dams and ponds on fish and fishing. Johnson, in his investigations in the Adirondack region, found great diversity in the ideas of the people in regard to this matter. Some claimed that the beaver ponds ruined the fishing, others that it improved it. It is possible that both opinions were correct, different physical conditions accounting for the discrepancies.

Regarding beaver ponds and fish, Dr. W. Lyman Underwood writes me that he knows of two instances where beaver ponds attracted trout. "One was in Maine on the headwaters of the St. Croix River. Here a small brook flowed through a meadow. A great many years ago there was a dam upon this stream and a sawmill beside it. The whole thing went into ruins forty or fifty years ago. Several years ago the beavers constructed a dam where the old lumber mill's dam once stood. There had been no fish in the brook in this meadow, but within a short time it became well stocked with trout and good fishing could be had there. Five or six miles below where the old mill had stood entered quite a large headwater stream. Here there had always been a goodly number of trout of fair size, but they never seemed to go up the small brook where the beavers finally made their home.

"The other instance of beavers being responsible for the stocking of ponds occurred in New Brunswick at the head of the Nepisquit River, some eighty miles from any habitation. Here were a number of beaver ponds where my guides told me that years ago, before the beavers had made the dams, there were no trout. When I visited them there was excellent fishing to be had and I frequently caught trout by

standing on top of the dam and casting my flies into the water above it.”¹

Mills says that after a severe winter in the Longs Peak region the only trout left in certain streams were those in the beaver ponds. I saw trout in those ponds myself. In other parts of Colorado where I have been I have seen trout in beaver ponds, even in some which were connected with the main stream by a mere rivulet.

Dugmore says the beaver ponds afford deep, cool retreats for trout in hot weather, and even though the dams may restrict the movements of the fish at times, there are always opportunities during the year for them to pass up or down.

“Fins, Feathers and Fur” does not think trout fishing in Minnesota is affected in any way by beaver dams and ponds, the temperature of the water always remaining low enough in summer for the trout’s needs.²

BEAVERS AND BIRD LIFE

Not much has been said or written as to the influence of beaver ponds upon bird life. Possibly they have comparatively little, but such as it is, it probably is beneficial. As one would naturally expect, various species of ducks are found about the ponds, especially in migration. In the Yellowstone I saw mallards about some of the ponds in summer, including a brood of young on one pond. The same species was also seen on ponds, in the Longs Peak region. In the Adirondacks, Johnson saw broods of black ducks which probably were locally hatched, also occasional hooded mergansers and American golden-eyes. He says the great blue heron was common and the solitary sand-

¹ From letter from Doctor Underwood.

² December, 1922, p. 3.

piper fairly common. In the Yellowstone I saw both the solitary and spotted sandpipers, the former late in the summer, after the fall migration had begun. The latter was a summer resident, and seen not only at the beaver ponds, but along all the streams.

Beaver ponds are likely to create along their shores conditions which will attract some of the swamp or marsh-loving warblers and sparrows, and induce them to nest there.

CHAPTER XII

BEAVER FUR; CASTOREUM; BEAVER MEAT; BEAVER FARMING

BEAVER FUR

Almost from the very beginning of the settlement of North America the trade in beaver skins played a most important part in the development of the country, especially of Canada and the western United States, where the search for the coveted furs sent the trappers into practically every nook and corner of the Rocky Mountains.

The French, when in possession of Canada, were indefatigable in their pursuit of the animal, and the Hudson's Bay Company, when it came into being, likewise devoted much attention to the gathering of beaver skins. For a long series of years beaver fur furnished the material for hats, until in the nineteenth century the manufacture of silk for hats, and the use of the fur of the South American nutria or coypu combined to force the beaver from its place as a hatter's material, and one may say compelled its use exclusively for wearing apparel, a purpose for which it is eminently well adapted, being one of the best furs we have.

In Canada trading began in 1603 under a Royal Charter (French), and about twenty-five years later the "Company of 100 Partners" was formed, which took over and developed the trade until 1663. After some changes Montreal became the capital of the Canadian fur trade.

May 2, 1669, Charles II of England granted Royal Charter to the Governor and Company of Hudson's Bay, which granted exclusive rights in commerce and trading in that whole vast region.

While of course many other furs were taken the beaver was of such prime importance that everything, both other kinds of furs and articles of merchandise, was valued in terms of beaver skins. Beaver tokens were issued by the fur companies for use in trading. Beaver skins in the early days of the trade began to be sold by the pound, and the custom survived to a comparatively few years ago. The average weight of a beaver skin is $1\frac{1}{2}$ to $1\frac{3}{4}$ pounds (*Castorologia*).

From 1853 to 1877, inclusive, the Hudson's Bay Company sold 2,965,389 beaver skins in London, the average being 118,615 skins annually. The maximum, 172,042, was in 1867, probably the most productive year of the company. The numbers fell off, and in 1897 the company sales were about 50,000, in 1900 about 43,000, 46,000 in 1902, and 49,190 for 1903. The above figures are from MacFarlane.

Seton says that in the last quarter of the eighteenth century about 150,000 skins were exported annually by American fur companies, and the Hudson's Bay Company marketed about 50,000 yearly.

In 1891 the American output was reduced to 11,693, and the Hudson's Bay Company's was 57,260, while in 1887 it had exported 102,745, and in 1871, 171,461 skins. In 1905 the Hudson's Bay Company's returns were 54,119.

Dugmore says that in 1859 there were 509,000 sold in London and Edinburgh.

At the London fur sales in March, 1906, prices were \$7.20 to \$8.40 for first-class skins, grading down to \$3.60. Forty-one first-class black skins brought \$14.88 each. Since that date prices have greatly advanced.

Thanks to the kindness of David C. Mills, general director of the National Association of the Fur Industry, I have very complete data of the sales of beaver skins of the New York Fur Sales Corporation for the five years 1919-1923,

inclusive. Sales are held three times in each year (the autumn sale was omitted in 1920). The lowest average price for all grades of skins was \$12.03 at the sale of January 17, 1921. The highest average price was \$40.70, February 25, 1920. They dropped to \$31.28 at the sale of April 27, 1920, and then to the above mentioned minimum, \$12.03, the following January.

The highest price at which any skins were sold was \$64.00 each for forty of the highest grade skins, at the February, 1920, sale, while at the same sale fifty-two of the lowest grade pelts brought \$8.50 each, dropping to \$2.50 at the sale of the following April.

Prices in 1923 averaged between \$15 and \$16, with a maximum of \$27.75 for 76 skins, and a minimum of \$1.00 for 162, both of these prices being obtained at the September sale.

As a matter of fact, after the drop of January, 1921, and the subsequent moderate recovery at the following sales, prices have been fairly steady, averages ranging from \$14.46 to \$21.09, with a maximum for the best of \$35.50.

The skins were sold in lots, and labeled I, II, III, IV and Cubs (and often also, large, medium, small and dark).

The total number of beaver skins sold during these five years was 115,097, an average of 23,019.4 skins annually.

The fur traders, in the early part of the nineteenth century, put the beaver skins in packs weighing one hundred pounds each. James, in the account of Long's Expedition, says there were seventy to eighty skins in a pack. He says the usual price per pound in St. Louis was \$3.00. This was about 1820. Maximilian says there were generally sixty large pelts in a pack, and the usual price was \$4.00 a pound.

Some of the early writers on the Far West tell us what the traders paid for beaver skins. Alexander Ross, one of the party sent out by J. J. Astor on the expedition which founded

Astoria, mouth of the Columbia River, in 1811 to 1814, says that at Fort Kamloops he bought one hundred and ten beavers for leaf tobacco at the rate of five leaves per skin, and at the last, when he had but one yard of white cotton remaining, a chief gave him twenty prime beaver skins for it.

Father DeSmet tells us that in 1843 the beaver skin sold for nine or ten dollars worth of provisions, the real value of which was less than a single dollar. "For a gill of whiskey, which has not cost the trader more than three or four cents is sometimes sold for three or four dollars, though the chief virtue it possesses is to kill the body and soul of the buyer."

Farnham related that at Pueblo, Colorado, in 1839, a pint of whiskey was paid for a beaver skin, value \$4.00. Townsend said they traded trifles costing $12\frac{1}{2}$ cents for beaver skins, worth in Boston \$8 to \$10. This was in 1833.

The possibilities of developing the supply of beaver fur by enforcing a close season and the permitting of a limited amount of trapping under license, are shown by the following figures from the Minnesota Department of Conservation:

1919-20, 361 pelts @ \$35.00.....	\$12,635.00
1920-21, 1200 pelts @ 20.00.....	24,000.00
1921-22, 3533 pelts @ 18.00.....	63,594.00
Total.....	<hr/> \$100,229.00

The estimated catch for 1922-23 was eight thousand pelts, valued at \$200,000, which appears to me to be too high an estimate.

Previous to the enforcement of a close season beavers were practically extinct in many localities in Minnesota.

In most of the states the beaver is protected, and trapping either forbidden, or allowed under restrictions. This has resulted in an increase in the numbers of the animal, and provides a supply which might be drawn upon for fur. If this matter is handled intelligently we should have a constant supply of beaver fur.

At the present time fourteen states have an open season for the trapping of beaver. In twenty-five, including every one of the Rocky Mountain States, the animal is protected at all times, excepting that in most of the western states permits may be issued for the taking of beavers injuring or destroying property. In Minnesota and New York beavers may be trapped under special license; in a part of Oregon they may be trapped, and in the other part trapping is forbidden. The beaver is not mentioned in the game laws of seven states, all of them old communities where the creature was long ago exterminated.

In Canada five provinces permit the taking of beaver during open seasons, and it is protected at all times in five others. There is an open season in the northern part of Manitoba, and none in the southern.

The Northern District of Lower California has an open season on male beavers only. The law does not specify how the sex may be determined before the animal is captured.

MacFarlane says that for more than a decade subsequent to 1821 each beaver district in the territories of the Hudson's Bay Company was restricted to the annual collection of a fixed number of beavers. This eventually proved to be of much benefit. After the beavers were known to have increased much in numbers the rule was gradually relaxed. "It may be here mentioned that the Company never encouraged the hunting of beaver or any other pelt *out of season*. On the contrary they strictly prohibited the killing of beaver in summer, and would only reluctantly accept the skins of such animals as they were assured had been absolutely necessary for food purposes."

MacFarlane also says that skins taken by natives of Quebec who resort to Bersimis Post in the Gulf of St. Lawrence are among the very finest. Labrador, East Main, and other Hudson Bay posts also furnish a small number of

similar pelts. "As a rule, those which frequent clear-water streams have a better color than is the case with the summer inhabitants of very muddy rivers having their source in or beyond the Rocky Mountains and flowing through a sandy clay soil. The skins of such beaver are usually of a rusty brown color, with the inner fur of a lighter hue, and are certainly in appearance inferior to their cleaner-furred brethren and must therefore realize lower prices in London."

CASTOREUM

While of course it is not a fur, castoreum has always been traded in by the fur buyers, and the amounts handled may well be treated in this chapter. The following figures taken from MacFarlane show the amounts handled by the Hudson's Bay Company in part of its territories:

	<i>pounds</i>
Mackenzie River District (1863 to 1881).....	6,251
Old Athabasca (1858 to 1884).....	18,904
Average of Mackenzie River (1886, 1887 and 1889).....	54
Average of Athabasca (1885 to 1889).....	211

There was much falling off in the eighties, the result of "free trade."

David Mills informs me that there has been no market for beaver castors since 1914. In December, 1923, 1800 pounds were offered in London by Lampson's, and about 100 taken. In New York absolutely no movement has taken place. Ten years ago they brought \$10 to \$20 a pound at London, but now (March, 1924) the owners are holding for but \$4 to \$6 per pound. It is possible a few small sales might be made at \$2.50. Really no "price" exists and fur buyers quote no prices for beaver castors. There are about six pairs of castors to the pound.

A book called "Castorologia" was published in 1685, which was a treatise on the medico-chemical uses of the

beaver. Castoreum apparently cured many things, and the fat and blood also were used, the latter for epilepsy. The teeth were attached to the necks of children to facilitate the cutting of teeth.

The following analyses of Castoreum are from Watt's Dictionary of Chemistry:

	Russian castoreum	Canadian castoreum
Volatile oil.....	1.00	2.00
Castoreum resin.....	13.85	58.60
Cholesterin.....		1.20
Castorin.....	0.33	2.50
Albumin.....	0.05	1.60
Glutinous substance.....	2.30	2.00
Extract soluble in water and alcohol.....	0.20	2.40
Carbonate of ammonium.....	0.82	0.80
Phosphate of calcium.....	1.44	1.40
Carbonate of calcium.....	33.60	2.60
Sulphates of potassium, calcium and magnesium	0.20	
Gelatinous substance extr. by potash....	2.30	8.40
Gelatinous substance extr. by potash soluble in alcohol.....		1.60
Membranes, skin, etc.....	20.03	3.30
Water and loss.....	22.83	11.70
	<hr/> 98.95	<hr/> 100.10

BEAVER MEAT

Beaver meat is said to be very good eating, and the tail is a traditional delicacy among trappers and hunters. Never having tasted either I can not say anything from personal experience. Bailey says the body meat has rather a gamey flavor, and was generally preferred by trappers to any other meat, even in early days when other game was abundant. He says the liver is as good as that of a chicken or goose. The tail is fatty tissue, very rich. Seton likens the tail to calf's head with marrow dressing, decidedly rich and heavy, but delicious eating. He says: "In a vast portion of the Mackenzie Valley the beaver serves the Indians

as the buffalo did those of the plains. It is their staff of life, it feeds and clothes them, as well as supplies the necessary peltry to barter with traders for other things desired. These tribes are very naturally known as the 'Beaver Indians.'"

Howell says that in Alabama the flesh of the beaver is eagerly sought for food, especially by negroes on the plantations. Johnson considers the meat very good. A correspondent writes that beaver meat is very good, but very rich and that the saddle of a yearling roasted is "pretty dainty."

Bailey suggests that beaver farmers could make the meat a source of income, selling that of the animals killed for fur.

I have been told that years ago in Colorado some people used to cook beaver tails, then soak them in vinegar, and thus prepared they were excellent eating.

Pattie speaks of carrying dried beaver meat for provisions when on the Colorado River in southwestern Arizona. DeSmet said that the feet were the most dainty parts, and that the tail afforded a substitute for butter.

BEAVER FARMING

Beaver farming is a subject of which I must confess a lack of personal knowledge, nor do I know of anyone who has had any experience, at least for any length of time, in the occupation of raising beavers for their fur.

It is at least theoretically possible to procure some beavers, place them in an enclosure where there is water, also trees or bushes suitable for food, allow them to multiply, and when the time comes, kill a number and market their pelts. Whether this can be done profitably remains to be demonstrated.

The Biological Survey of the United States Department of Agriculture has published a bulletin by Vernon Bailey in

which the subject of beaver farming is taken up, and in which helpful suggestions are given.

The important thing in establishing a beaver farm is to have a sure supply of water, a pond, lake or stream which can be enclosed in some way so as to prevent the escape of the animals. The water should be of such a depth naturally, or the situation such that the beavers can, by damming, make the water deep enough to prevent freezing to the bottom. Growing trees or bushes for a food supply would be a great advantage, though perhaps not essential. Brush might be cut elsewhere and placed in the enclosure, and also other food supplied. Willows grow fast, and quickly replace themselves after cutting.

The matter is one which is well worth trying out in an intelligent manner, but whoever undertakes it must be prepared to wait several years, very possibly as many as ten, before he will really know whether or not he has embarked in a profitable enterprise.

CHAPTER XIII

THINGS THAT A BEAVER DOES NOT DO

The beaver has been credited with—or shall I say accused of?—doing many preposterous things, and other things which, while not preposterous, it would be rather foolish to believe. All sorts of queer stories have been told about the animal, some without anything in the way of a reason for their being.

It is a popular notion that a beaver works all the time. No such thing. He is too wise to do anything so foolish. He works when he has to, and works hard then. But he likes to loaf and play, and I suspect spends a lot of time doing so. Perhaps this goes to show his intelligence.

The tail is not used as a trowel, to drive stakes with, or as a sled to carry mud or other materials upon.

He is not a weather prophet, he can not foretell whether or not next winter will be a hard one.

He does not suck the air from wood in order to make it sink. Anyone who would take the trouble to observe the size of a beaver's mouth would at once see how ridiculous such a notion is.

He does not fell trees across a stream in order to construct dams against them. In a certain book for young folks about the beaver, one chapter has an entertaining account of how a pair of young beavers started out to make a home for themselves. How they traveled up the stream looking for a place where a dam could be built and a pond formed, is graphically told. At last they came to a place which suited the bridegroom, who apparently was the more experienced of the couple. He first felled a tree on one bank so that it

dropped across the stream, its branches hanging in the water. Then he went over to the other side and cut another tree so that it fell into the water just above the first, when it drifted down against the latter, and their branches became entangled, making a fine beginning for a dam. All very nice, but I suspect the author made liberal drafts upon his imagination in writing that story, for it is just the way a beaver does not go about building a dam.

Beavers eat no fish or other animal food.

When caught in a steel trap a beaver does not gnaw its foot off, but twists it round and round in its struggles to escape until it finally pulls the foot off. It is always the fore foot which is thus amputated, and the act is accidental, not intentional.

Beavers do not gnaw a tree partly through, and then wait for the wind to blow it down.

A beaver does not sleep in the lodge with its tail in the water so as to have warning of a break in the dam by the consequent drop in the water level. Yet I have seen a statement to this effect in a paper of large circulation.

John Bradbury, an Englishman who traveled in the west in 1809, 1810 and 1811, in speaking of the knowledge of the hunters of the various animals concerning their habits, says: "They state that an old beaver, who has escaped from a trap, can scarcely ever afterwards be caught, as traveling in situations where traps are usually placed, he carries a stick in his mouth, with which he probes the sides of the river, so that the stick may be caught in the trap."

The hunters also said that the young beavers are educated by the old ones. "It is well known that in constructing their dams, the first step the beaver takes is to cut down a tree that shall fall across the stream intended to be dammed up." Same old story! The hunters said they often found trees partly cut and abandoned, and these would not have

fallen across the creek. Tooth-marks on the stumps showed the work was done by young beavers. The old ones made them stop because the tree would not fall over the water. The trappers showed Bradbury.

Father DeSmet in 1843 said: When they are about constructing a dam, they examine all the trees on the bank, and choose one that is most bent over the water on the side where they want to erect their fort. If they find no tree of this kind they repair to another place, or patiently wait until a violent wind gives the requisite inclination to some of the trees.

If one wishes he can find opportunities for nature faking stories as he studies the beaver's work and chooses to twist what he sees to suit his own purposes.

I happened on a chance of the sort in the Yellowstone one day. Two aspen trunks growing from one root had been cut partly through from opposite sides and had fallen in opposite directions. Not far from them another aspen had also been partly cut and had fallen. An unusually large aspen had fallen so that it lay over the single stump and between the other two. This large aspen had been so much decayed that only a shell of green wood was left on one side, and when this was cut the tree had fallen, and had happened to drop as I have described. An examination of the various logs showed that the large tree had not fallen until after the others, for these showed no marks which the large tree would undoubtedly have made if it had fallen first and brought the others down with it.

Now if I were a real good nature faker I might tell about it in this fashion:

Old Paddy Beaver was taking a look about his premises one day and came across these two aspens growing from one root, noticed the other, also the big one. He saw how little work it would take to fell the latter and that it leaned in

just the right direction to fall upon the other three. He said to himself, "Well, here's a chance to make a good killing with mighty little work. All I have to do is to cut those three trees partly through, a few bites will drop that big one right on them, and down they will come. That's dead easy."

So Paddy hustled out his gang of lumberjacks and put them to work while he stood around, bossed the job, and looked wise. The boys cut a little into one side of each of the smaller trees, then a little work on the proper side of the big one, and down it came just as Paddy had figured it would, and carried the other three with it in its downfall.

Paddy strutted around, looked almost as big as he felt and remarked, "You see, boys, it pays to have a good head on your shoulders. Now get busy and trim those trees and cut them into lengths."

All of which is just what did not take place.

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Sans Tache

Sans Tache

IN THE “elder days of art” each artist or craftsman enjoyed the privilege of independent creation. He carried through a process of manufacture from beginning to end. The scribe of the days before the printing press was such a craftsman. So was the printer in the days before the machine process. He stood or fell, as a craftsman, by the merit or demerit of his finished product.

Modern machine production has added much to the worker’s productivity and to his material welfare; but it has deprived him of the old creative distinctiveness. His work is merged in the work of the team, and lost sight of as something representing him and his personality.

Many hands and minds contribute to the manufacture of a book, in this day of specialization. There are seven distinct major processes in the making of a book: The type must first be set; by the monotype method, there are two processes, the “keyboarding” of the MS and the casting of the type from the perforated paper rolls thus produced. Formulas and other intricate work must be hand-set; then the whole brought together (“composed”) in its true order made into pages and forms. The results must be checked by proof reading at each stage. Then comes the “make-ready” and press-run and finally the binding into volumes.

All of these processes, except that of binding into cloth or leather covers, are carried on under our roof.

The motto of the Waverly Press is *Sans Tache*. Our ideal is to manufacture books “*without blemish*”—worthy books, worthily printed, with worthy typography—books to which

we shall be proud to attach our imprint, made by craftsmen who are willing to accept open responsibility for their work, and who are entitled to credit for creditable performance.

The printing craftsman of today is quite as much a craftsman as his predecessor. There is quite as much discrimination between poor work and good. We are of the opinion that the individuality of the worker should not be wholly lost. The members of our staff who have contributed their skill of hand and brain to this volume are:

Composing Room: William Sanders, Edgar Simmons, Anthony Wagner, Andrew Rassa, Austin Uhland, Ernest Salgado, Nathan Miller, Arthur Baker, Herbert Leitch, Edward Rice, Richard King, Theodore Nilson, George Moss, Walter Phillips, Henry Shea.

Proof Room: Sarah Katzin, Alice Reuter, Mary Reed, Ruth Treischman, Ethel Strasinger, Lucille Bull, Angeline Eifert, Audrey Tanner, Dorothy Strasinger, Lillian Gilland, Geraldine Browne, George Southworth, Ida Zimmerman, Catharine Miller.

Press: Clarence Ridgeway, Robert S. Gallagher, Raymond Gallagher, Fred Lucker.

Cutter: William Armiger.

Keyboard: Anna Rustic, Harry Susenihl, Eleanor Luecke, Vera Taylor.

Casters: Ernest Wann, Kenneth Brown, Mahlon Robinson, Charles Aher, George Smith, Frank Malanosky, Martin Griffen, Henry Lee, Charles Fick, George Bullinger.

Folder: Laurence Krug, Shipley Dellinger.

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NUMBER ONE

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By A. BRAZIER HOWELL
U. S. Biological Survey

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